J. Wilson Spaeth.

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ANAMORPHOSIS AND ITS USE IN FOREST GRAPHICS

BY DONALD BRUCE

Division of Forestry, University of California

Many problems in forestry are most easily solved by means of curves. The normal procedure in preparing these curves is to assign one of two correlated variables involved in the problem to each of the axes of a system of rectangular co-ordinates, and then to graduate these axes into arbitrary but uniform divisions. Where cross-section paper is used this is done by assuming that some definite number of squares is equal to 1 inch, 1 foot, or 1 of whatever unit is selected for measuring the variable. The interrelated values of the two variables are then plotted, and (except in cases where the underlying law is very simple) a curve is indicated thereby. This curve may be of any shape, although the forms characteristic of forestry are neither excessively numerous nor complex.

It is possible, however, to express any of these interrelations equally well by a straight line providing the uniformity of graduation of one or both of the axes is abandoned. This is illustrated by Figure 1, A and B, which are identical in their values, although A is curved and B is straight. This transformation of a curve into a straight line is known as *anamorphosis*.[1] The procedure thereof is simple and is illustrated in Figure 1 C. In this the same curve as in A is represented, referenced to a similar set of uniform co-ordinate graduations, all in solid lines. To anamorphose this curve a straight line is drawn across it in any position which coincides approximately with its trend. The graduations of the horizontal axis are then revised in such a manner that the straight line gives the same values as did the curve before. Taking the 2 graduation as an example: it is evident that

[1] Logarithmic cross-section paper is merely a special case of anamorphosis.

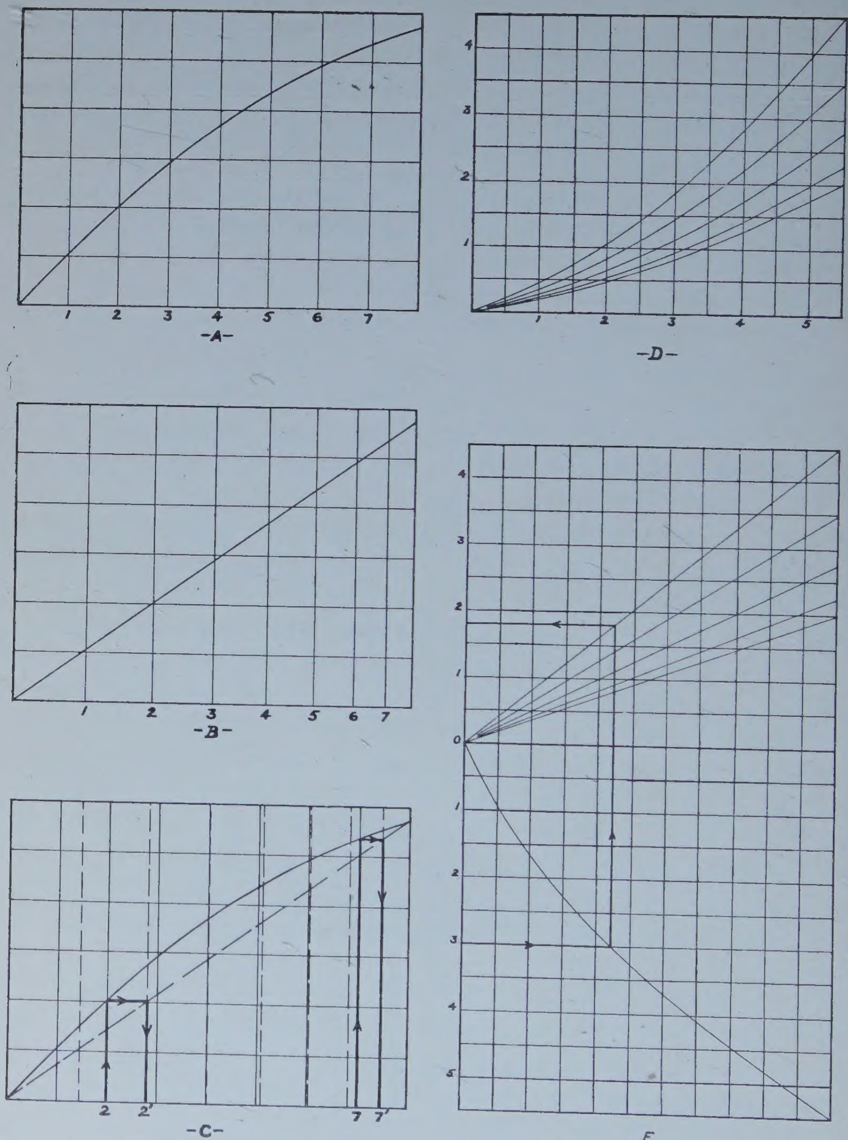

FIG. 1.—A, a curve in its conventional form; B, the same curve anamorphosed into a straight line; C, how the anamorphosis was accomplished; D, a series of harmonized curves; E, the same series simultaneously anamorphosed into straight lines by means of a single graduating curve.

the intersections of the straight line with the revised 2 graduation and of the curve with the original 2 graduation must be at the same number of verical units above the horizontal axis. One therefore starts at 2 on the base, goes vertically upwards to the curve, thence horizontally to the right to the straight line, and thence vertically downward to the axis again, this last point being the revised 2 (2′ on the graph). In a similar way the other graduations may be appropriately shifted. The heavy lines with arrows in the figure indicate the course of the eye in relocating the 2 and the 7 graduations. To avoid confusion, the straight line and the new graduations associated therewith are represented in Figure 1 C by broken lines.

It is evident that the precise position of the straight line is immaterial, although if poor judgment is used in locating it, the resulting regraduations may be either confusingly condensed or so expanded that they fall outside the limits of the paper. It is also evident that the regraduation process may be applied to either axis or even to both. It is seldom important which is chosen, but it is customary to select the horizontal, as this is less often read to fractional values. Lastly, it is apparent that a curve which first rises and then falls again is awkward to handle. Theoretically it may be anamorphosed, but in practice the resulting graduations will double back on themselves and become confused.

Obviously nothing has been gained by anamorphosis in the case just illustrated. While the curve has been simplified into a straight line, this has been at least fully compensated for through the complexity introduced by irregular graduations of the horizontal axis. This example therefore merely illustrates the fundamental principle and process, the advantages of which appear only in somewhat more complex situations.

Such situations arise in many problems which deal with three instead of two variables, as, for example, in that of a volume table based on height and diameter or of a growth table based on age and site. Graphs related to such problems usually present not one but a series of so-called harmonized curves, similar in form and regular in their progression. Very often it happens that when one of such a harmonized series is anamorphosed the regraduation of the horizontal axis will automatically serve to convert all the other curves of the series into straight lines. Where this simultaneous anamorphosis occurs, the advantage is evident. The complexity associated with each

of a number of curves has been replaced by a complexity limited to the graduations of a single axis. Figure 1, D and E, show a series of harmonized curves and the effect thereon of anamorphosis.

Figure 1 E also illustrates an additional device, that of a *graduating curve,* which occupies the lower half of the figure. For practical reasons some of the forms of printed co-ordinate paper must ordinarily be used in graphic work. It will often be found that to superpose a new grill of vertical graduating lines over that already printed leads to confusion and eyestrain. Figure 1 C illustrates this to a minor degree. This confusion may be reduced by using profile paper in which the printed verticals are less numerous, and by using ink of a distinctive color, but even this is somewhat unsatisfactory and in most cases the construction of a graduating curve is preferable. It has the additional advantage of facilitating the reading of fractional values.

In Figure 1 E the graduations expressing the two variables, instead of being at right angles in the usual manner, are both placed along the vertical axis, one leading upwards from O, and the other downwards. The latter series takes the place of the usual horizontal scale and therefore represents the independent variable. In reading the curves, one starts from any desired value on this lower scale, follows a horizontal line to the right to its intersection with the graduating curve, then follows a vertical line upward to its intersection with the appropriate straight line in the main graph above, and then, finally, horizontally to the left to the scale of the dependent variable. The heavy lines and arrows in Figure 1 E illustrate the method of reading the value (1.8) on the highest line of the graph corresponding to 3 of the independent variable.

The construction of this graduating curve is simple. The horizontal axis may first be temporarily graduated in the manner already described. The vertically downward axis is next graduated regularly and arbitrarily. The intersections of verticals dropped from the temporary graduations with corresponding horizontals projected from the downward axis will determine a series of points through which the graduating curve may easily be drawn.

A curve such as that of Figure 1 E makes more evident just what has been accomplished by such a transformation. A single curve has been substituted for a series of curves. The values of the straight lines differ, but the essential shapes of the curves for which they stand are identical; in other words they are perfectly harmonized.

Just how this fact may be utilized will appear in later paragraphs. It is first in order, however, to inquire how it may be determined whether any given series of harmonized curves may be thus anamorphosed in mass. The answer is easy where the underlying equation of the curves is known. It may be shown that simultaneous anamorphosis is possible whenever the equation is of the form

$$f_1(x) f_2(z) + f_3(y) f_4(z) + f_5(z) = 0$$

where x, y, and z are the three variables and f_1, f_2, etc., signify "any function of." It may also be shown that in the special cases thereof

$$f_1(x) + f_2(y) + f_3(z) = 0$$
$$\text{and } f_1(x) f_2(y) = f_3(z)$$

the resulting straight lines will be respectively parallel and radiating from the origin. Unfortunately, the foregoing criteria cannot ordinarily be applied to curves in forestry because they are based on empirical data and are of unknown equation. These considerations are of interest, therefore, merely as illustrating the very varied types of curves which are susceptible of anamorphosis, and as suggesting the consequent probability that any given harmonized series can be thus treated. The actual test in the case of empirical data is to anamorphose one curve and then by actual trial to see whether the revised graduations result in straight lines for the others. In most cases this result will occur and very frequently the straight lines will either be parallel or will radiate from the origin of co-ordinates.

Very commonly the several curves of a harmonized series are of varying reliability. In such cases it is obvious that the strongest should be the basis of the anamorphosis. In such cases, moreover, if the other strong curves become essentially straight lines, any divergence from this form on the part of the weaker curves need not be taken too seriously—it is probably due to inadequate data or to poor curve drawing, and in such instances the straight line suggested by the anamorphosis is an undoubted improvement over the original curve.

This consideration suggests at once the main field of usefulness of anamorphosis. Foresters are continually confronted with the problem of harmonizing curves based on somewhat meager data. Usually the central curves, being supported by the largest number of observations, are sufficiently well defined, but those toward the outer edges of the series are discordant. Their readjustment has commonly been treated

too much as an art instead of as a science, with the result that their harmonization has at times been incomplete or the data misinterpreted. By the use of anamorphosis in such cases, the element of human judgment is reduced to a minimum, and the process of harmonizing becomes nearly mechanical.

This process is best explained by an example. In a recent study of the yield of redwood it was found that of the five sites which were recognized, but three were represented by a material number of plots, and that of these three sites (I, II, III), site II contained the major portion of the data. When it became necessary to determine by curve drawing the average height at various ages in the three site classes, the conventional method would have resulted in one strong central curve, flanked by two much weaker curves which would therefore have been shaped largely by reference thereto. The central curve was therefore drawn first and anamorphosed into a straight line by means of a graduating curve. This straight line was passed through the origin, because it seemed probable that the resulting system would be of the radiating type. Using the graduating curve, the original data for sites I and III were plotted and a straight line passing through the origin was easily fitted to each series of points. Figure 2 shows the anamorphosed curve for site II, the graduating curve, the points representing the original data for sites I and III and the final straight line curves fitted to the latter. If the figure be redrawn on ordinary co-ordinate paper with a uniform horizontal scale it will be found that the corresponding curves fit the data as well as could be hoped and that they are perfectly harmonized. Moreover, it is obvious that even with the scantiest of data a fair approximation to the curves for sites IV and V could have been added, and it is clear that had the data for either sites I or III been even more limited in range, extrapolation would have been easy and safe up to the limits of the range of the site II curve.

Figure 3 illustrates an instance where the curve form is quite different and where the resulting straight lines are neither parallel nor radiating. It is an anamorphosis of the interesting graph presented in the March, 1923, issue of the JOURNAL by H. R. Wickenden, on page 261. In this case the graduating curve is omitted and a revised vertical grillwork constructed from the height curve is shown instead. The exact points for the 3, 6, 9, 12, and 15 inch curves are indicated by small crosses. Their coincidence with the straight lines is not

perfect but on examination their departure therefrom will be found to be not only of minor importance, but also, what is more significant, to be irregular in trend. This justifies the conclusion that the failure to coincide is accidental and not due to any inapplicability of the principle of anamorphosis to this particular case. It therefore follows

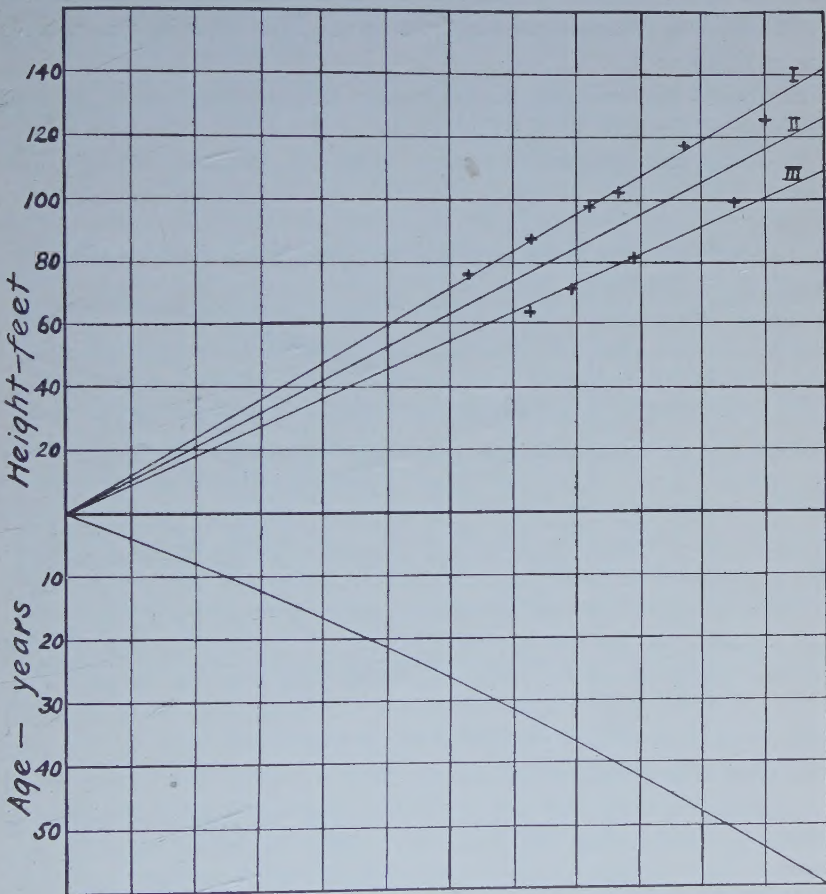

FIG. 3.—The use of anamorphosis in constructing curves showing the relation between height and age for three site qualities.

that anamorphosis might profitably be employed in preparing such a graph.

It is unnecessary to multiply instances, for new possibilities of application will constantly occur to the forester who has mastered the simple technique involved. It may be helpful, however, to call attention

to two variations of not infrequent occurrence. The first has to do with cases where no one curve of the series investigated is predominating and satisfactory, but where, rather, the several curves are of approximately equal strength. In such instances improved results are possible by a process of successively approximating the graduating curve and the straight line series in turn. The steps in this process are as follows:

1. Choose the strongest of the curves and anamorphose it by constructing a tentative graduating curve.

2. Using this graduating curve, locate a tentative straight-line system.

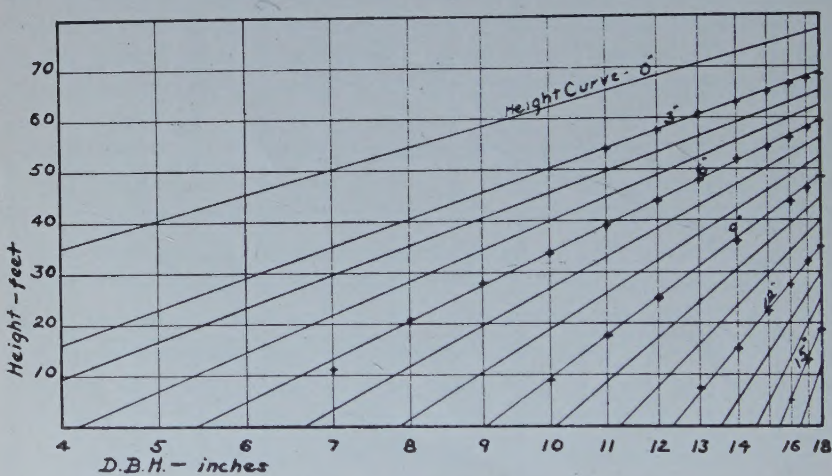

FIG. 3.—An anamorphosed stand taper chart.

3. Erase the tentative graduating curve.

4. Using the tentative straight-line system of step 2 relocate the graduating curve, but this time plot points therefore from all the straight lines instead of as originally from the strongest line only. The result will be a narrow and well defined zone of points through which a revised graduating curve may readily be drawn.

5. Erase the tentative straight line system.

6. Relocate the straight line system on the basis of the revised graduating curve.

7. If necessary, repeat steps 3 to 6; normally the results of 6 will be satisfactory without this repetition.

A second variation is desirable in such a case as that of volume tables where different curves are strong opposite different portions of the horizontal scale. In such cases considerable ingenuity may be exercised in taking care of peculiarities of the distribution of data, etc., in each individual case. The following process, which illustrates the method of attack adopted in one actual case of volume table preparation, is merely suggestive:

1. The curves of volume over d.b.h. for the several height classes were drawn on a single sheet, as in the conventional method of volume table preparation.

2. On examination it was found that above each portion of the scale expressing diameters some one of the curves was particularly well established. These portions of five different height class curves were therefore chosen as guide curves, being so selected as to cover completely the diameter range, with a slight overlapping at points where one curve was abandoned and another adopted.

3. Starting with the upper guide curve a substitute straight line was drawn in any convenient position but passing through the origin. From this the corresponding portion of the graduating curve was located in the manner already described.

4. When the end of this portion of the graduating curve was reached a second straight line was located as a substitute for the next guide curve. Its position was obtained from the portion thereof that overlapped the first guide curve, and hence the part of the graduating curve already drawn. This line also passed through the origin.

5. The remainder of the second straight line was then used to construct an additional portion of the guide curve.

6. The process was repeated for each guide curve in turn in each instance first substituting a straight line therefor and then using this to construct a corresponding portion of the graduating curve.

7. The completed graduating curve, which was slightly irregular in form, was then smoothed out.

8. As this adjustment of the graduating curve had disturbed its interrelation with the series of straight lines, the latter were now erased and completely relocated. To do this the original data was used, each point determined thereby being plotted by means of the final graduating curve. The resulting zones of points were readily expressed by means of a revised system of radiating straight lines.

9. These resulting straight lines were now of course equivalent

to curves which were perfectly harmonized in form but which perhaps were not perfect in their spacing. If the values taken from these lines were used, that is, to draw curves of volume over height for the various diameter classes, the results might be irregular. Due to the form of the anamorphosed curves, if any one of these diameter-class curves be adjusted, the remainder will be automatically cared for by the same process. One curve, chosen at random, was therefore drawn in a separate graph and the values smoothed out in the usual way, due attention being paid to the relative weight of the height-class curves from which each point came.

10. The indicated shift of the straight lines in the original graph was now performed. The result was a perfectly harmonious set of curves from which the volume table could be read.

The process just described was rather laborious and it is possible that the results hardly justified the work involved therein. It is given, therefore, merely to illustrate the flexibility of the anamorphic method in cases which depart from the type first described.

In appraising this method its dangers and the objections to its use should be as clearly recognized as its advantages. Like all things of value it may be misused and poor results may be secured with it. The chief danger, of course, is that of using it in cases to which it is not properly applicable. If this is done the curves will be forced into a false shape. Constant alertness is necessary to recognize this condition when it occurs so that the method may be abandoned. The danger sign is not so much a failure of the points on the curves to fall into a linear zone when anamorphosed as some regularity in their manner of departing from this form. Experience, too, is often a guide. In the case, for example, of yield table curves of volume over age by site classes the use of this method will so completely harmonize the curves that the age of culmination of current annual growth and of mean annual growth will be the same for all sites. As this is contrary to experience, the method should be used in such cases only where the data is too weak to permit any determination of the differences in these ages due to site quality.

Minor drawbacks are the amount of labor involved in the process (which, however, is material only in extreme cases), and the fact that the straight lines present their data less vividly to the eye. This latter objection is only apparent in case the graduating curve is used, for this

latter, turned on its side, will be found to duplicate (except for difference in scale) the form of the original curves.

The advantage of anamorphosis, on the other hand, is that, in cases to which it is applicable—and they are many—it is a powerful mechanism for perfecting the harmonization of curves with a minimum danger of misinterpreting the basis data. Incidentally it facilitates interpolation and permits a considerable amount of extrapolation with unusual ease and certainty.

REPRODUCTION WITH FIRE PROTECTION IN THE ADIRONDACKS

By Joseph Kittredge, Jr., *Lake States Forest Experiment Station, U. S. Forest Service,* and Harold Cahill Belyea, *New York State College of Forestry.*

Much of the spruce slope type in the Adirondack Mountains of New York has been cut over or culled for the large spruce at least once and often twice. Recent cutting operations have taken larger and larger proportions of the spruce and also the balsam fir and some birch. As a result, the proportion of soft wood species is rapidly diminishing and consequently a change in the composition of the future Adirondack forest is imminent. The demand for spruce for paper pulp and other products to supply important permanent industries, makes the question of the present condition and probable future growth on these lands one of great interest. In order to secure data to throw light on the series of problems underlying this question, the New York State College of Forestry and the U. S. Forest Service in June and July, 1922, cooperated in studying representative cut-over areas in the upper spruce slope type which had not burned since cutting. Twenty areas in the region lying between Wilmington and Mount Whiteface on the north, Newcomb and Mount Vanderwhacker and Severance and Mount Hoffman on the south, were examined intensively. They represented cuttings in 1862, 1870, 1876, 1887, 1892, 1895, 1909, 1910, 1912, 1915, 1917, 1918 and 1920. Valuable suggestions of areas were received from several persons familiar with the region, particularly from A. S. Hopkins, Forester of the New York State Conservation Commission, and from Howard Churchill of the Finch-Pruyn Company.

On each area counts were made by size classes and species of the numbers of trees standing, windthrown, and cut. The larger sizes were tallied on strips one chain wide and the young growth on sample plots a square rod in area, spaced at definite intervals along compass lines run roughly perpendicular to the contours.

The upper spruce slope type occurs at elevations from 2,300 to 4,000 feet. The slopes vary from 10 to 70 per cent. There is a characteristic layer of humus from 1 to 3 inches deep over a loamy and usually rather shallow soil, frequently broken by rock outcrops. The virgin stands contain from 300 to 400 trees per acre from 1 to 24 inches d. b. h.

(diameter breast high), of which 80 per cent is red spruce and balsam fir. The balsam as a rule does not exceed 12 inches d. b. h. Paper birch, chiefly 10 inches d. b. h. and over, occurs quite commonly. Under the main canopy there is abundant advanced growth of all ages, mostly less than 6 inches high. The amount of this advanced growth varies from 4,000 to 20,000 stems per acre, of which 80 per cent or more is spruce and balsam.

The establishment of young growth was prevented on parts of the areas studied by the presence of slash or undergrowth. Slash was evident on all areas less than 14 years and one area 30 years after cutting. Piles of slash occupied from 5 to 38 per cent and averaged 14 per cent of the cut-over areas. They effectively prevented the establishment of most or all of the young growth on the areas occupied by them. Mountain maple (*Acer spicatum*) and fern (*Aspidium*), among the species of undergrowth, seemed to interfere most seriously with the reproduction of tree species. They occurred only in small patches, however, and did not affect more than a maximum of 10 per cent of any cut-over area. The figures which follow represent the averages of what was actually found on the ground on each area as a whole without allowance for failure of reproduction due to slash or undergrowth.

The cuttings took from 20 to 200 trees per acre of which at least 75 per cent was spruce. Most of them were over 11 inches d. b. h. In the more recent cuttings, however, as many as 150 trees to the acre between 6 and 10 inches d. b. h. and 80 trees to the acre between 1 and 5 inches d. b. h. were sometimes cut. In the smaller sizes as for the average of all sizes, spruce was cut most heavily. In considering the future possibilities of growth on these areas in connection with our observation that the largest proportions of spruce reproduction occurred on the areas where the largest representation of spruce had been present in the old growth, this heavy cutting of the smaller sizes of spruce is particularly significant. The process is unquestionably reducing the proportion of spruce in the future stands.

Windthrow as a result of the cutting has taken a part of the trees that were left in some cases. A maximum of 55 windfalls to the acre since cutting was noted on one area. In general, however, the loss from windthrow has not been serious, since the future stand of timber on these areas will come almost wholly from the trees which, at the time of cutting, had not yet attained a size to be subject to windthrow.

For spruce, an analysis of the counts shows that there were on the

average for all 20 areas, 3,140 trees to the acre less than one-half inch d. b. h. The minimum on any area was 320 to the acre and the maximum 9,245. Between 1 and 5 inches d. b. h. there were 190 spruces on the average, between 6 and 10 inches d. b. h. 27, and 11 inches or over, 4 to the acre. Several of the areas contained no spruces over 6 inches d. b. h.

Balsam was represented with an average of 7,700 trees to the acre below one-half inch d. b. h. The minimum of this size class was 534 and the maximum, 45,200 to the acre. There were on the average 313 balsams to the acre between 1 and 5 inches d. b. h., 22 between 6 and 10 inches, and 1 over 11 inches. As in the case of spruce, no balsams over 6 inches d. b. h. remained on several of the areas.

Paper birch had an average of 9,150 trees to the acre below one-half inch d. b. h. and a maximum in this size of 32,340 on one of the areas. There were also areas where paper birch in the seedling stages was not represented. Between 1 and 5 inches d. b. h. there were on the average 328 paper birches to the acre, between 6 and 10 inches, 27, and 11 inches or over, 5 to the acre.

Yellow birch is found at the lower elevations in the upper spruce slope type where it replaces paper birch to a large extent. It was, therefore, absent in the areas at higher elevations where paper birch was abundant. In spite of this fact yellow birch averaged 1,730 trees to the acre less then one-half inch d. b. h. and had a maximum on one area of 14,232 trees of this size to the acre. The average in the 1 to 5 inch class was 70 to the acre, in the 6 to 10 inch class, 8, and in the class 11 inches and over, 4.

Other species, including five cherry, hard maple, mountain ash, and aspen were found irregularly. On some areas they were entirely absent, and on others, abundant. The average numbers of trees of these minor species for the four size classes beginning with the one-half d. b. h. and less were 1,090, 125, 9, and 4.

In relative abundance paper birch and balsam were the dominating species. Balsam was found on every area examined with 534 or more trees to the acre less than one-half inch d. b. h., followed by spruce with 320 as a minimum. Balsam also had the highest maximum of 45,200 to the acre of less than one-half inch d. b. h., although paper birch occurred more abundantly on the average for all areas. Paper birch also was most abundant in the three larger size classes although it was equalled by spruce with an average of 27 trees to the acre in the 6 to 10

inch d. b. h. class. This high average for spruce was due to the lighter cuttings which were made in the earlier operations. Fortunately the paper birch, which grows more rapidly during its early life, does not wholly crowd out the smaller spruces and balsams so that, on the areas studied without exception, there is the promise of new stands of birch, balsam, and spruce.

For all species and all sizes the average number of trees to the acre on the 20 areas studied was 24,400. The maximum on any one area was 58,577 and on no area were there less than 3,846 trees to the acre.

The conclusions which may be drawn from the study are, first, that young growth is occupying the cut-over and unburned areas of the spruce slope type in the Adirondacks and will undoubtedly reclaim them to high forest stands of valuable species if they are protected from fire. Second, birch and balsam in about equal numbers are the two species which are most abundant in the reproduction. Third, the proportion of spruce in these stands is 10 to 15 per cent, which is much smaller than it was originally in those which have been cut. Finally, in order to maintain the representation of spruce which is established and to assure the development and maximum growth of the best individuals of this and the other species, the application of silvicultural measures will be needed periodically as the young stands develop.

ENTOMOLOGY AS AN AID TO FORESTRY

By C. S. Judd

Superintendent of Forestry, Hawaii

I have just read H. B. Pierson's excellent article in the May Journal on the importance of forest entomology to foresters and, in addition to refreshing my memory on all the bad things that insects do and the unspectacular and insidious manner in which they execute their work of destruction, I was reminded of that catchy little ditty that Thornton Munger once taught the eastern Oregon sheepherder who thereupon for several nights bawled it out to his sheep in the expansive yellow-pine groves of the Blue Mountains:

"Here's to the beetle Dendroctonus
Who lives in the bark of the pine.
He feeds on the sap, the son-of-a-yap
And he's harder to kill than a lion."

And Mr. Pierson has not one favorable word to say for any good insect.

Out here in the sub-tropics of the Pacific Ocean we have insect pests as elsewhere. We have real pernicious bugs that attack sugar cane, our leading agricultural crop, a fruit fly that spoils our mangoes and oranges to some extent and of which California is deathly afraid because of her citrous crops. We have army worms that deprive our beef cattle of their just abundance of forage, a pernicious horn fly that maks life miserable for them, a nocturnal "Japanese beetle" that makes the culture of roses impossible except by the aid of artificial light, a melon fly that long ago put the price of watermelons up to 5 cents per pound in the Honolulu market, and a myriad of others.

We have not, however, been discouraged over the damage caused by these winged scourges but have turned for control measures to the natural insect enemies and have searched in the original home of each and brought back, colonized and liberated the natural parasites which keep them in check.

The entomologists of Hawaii have probably had greater success in this work than have those in other parts of the world and in their wide-world searches during the past twenty years the local "bug-men"

have made some noteworthy and very successful introductions. These include parasites on the sugar cane leafhopper, a tachina fly parasitic on the sugar cane borer, several parasites on the Mediterranean fruit fly and on the melon fly, many parasites on scale insects, parasites on armyworms and cutworms, a scolia wasp parasitic on root-grubs, many ladybeetles predacious on plant lice, mealybugs and scale insects, several parasites on bean weevils, and parasites and predators on the cattle fly and other pernicious flies. The remarkable fact is that most of these introduced parasites and predators are successful in keeping the pests under control.

An excellent example of beneficial insect work aided by human intelligence occurred recently in connection with the control of a severe attack on forest ferns by a weevil which found its way to Hawaii from Australia over a decade ago. Usually this pernicious weevil, *Syagrius fulvitarsis,* with a hard, crusty snout, had damaged only maidenhair and other potted ferns around habitations with the exception of the ferns on the lower mountain slopes back of Honolulu where the *amaumau* had been almost entirely killed out by the pest. Suddenly a new focus of infestation was found on this same species of fern at the edge of the wet forest near the volcano of Kilauea, on the island of Hawaii, where the weevil seemed to be particularly voracious. It was thought at first that the infestation which was assumed to occupy only a small area could be wiped out by destroying the colony with fire and starvation, and a gang of men was employed to cut and burn all the *amaumau* ferns in which the weevil bred and used for food and also the tree ferns, on the tender fronds of which it seemed also to feed.

This was done under difficulties caused by rainy weather and a labor shortage. As added precautions, the ground was scorched by a force pump fire spray and a belt of crude oil poured over the ground at the circumference of the infestation.

New regions of infestation came to light, however, after more careful inspections and this intensive control work which lasted several months was extended over an area of 18 acres at a total cost of $7,000 before it was finally abandoned without the last weevil being killed.

From the first, we naturally were on the alert for a parasite on this weevil but inquiry of entomologists in Australia bringing negative results, C. E. Pemberton, of the Hawaiian Sugar Planters' Association experiment station staff, who was then in Australia, was asked

to keep on the watch for a natural enemy. With Yankee persistence he promptly proceeded twenty miles up the tributaries of the Richmond River in northern New South Wales and picked up an effective parasite on the larva of the weevil. There the parasite, an *Ischiogonus*, was keeping the weevil well under control and the ferns looked healthy everywhere in the wet, dripping forests. Mr. Pemberton at once gathered up a colony of the parasite, and the shipment which was forwarded by the first boat was received in Honolulu in May, 1921, colonized again, and liberated in the infested regions. Subsequent examinations have proved the effectiveness of this parasite and we are assured that by virtue of this natural enemy this pernicious weevil will never again be a dangerous uncontrolled pest in the Hawaiian forests.

But probably the most romantic and the most spectacular entomological stunt pulled off in our fair islands has been the employment of insects to furnish us with fertile forest tree seed. Here in Hawaii, where forest protection for water conservation, rather than growing trees for timber production, constitutes the main theme, our chief concern is to keep the forests in the best possible shape so as to function as efficient water conservers. Depredations on the very susceptible native forests caused by cattle are progressively being overcome by fencing forest boundaries and driving out or killing wild stock.

A much more serious problem is the dying off of large areas of the indigenous forest due to more intangible causes. This may possibly be the result of changes in drainage conditions in the soil, the cracks and fissures in the sub-surface lava flows being gradually filled up with fallen detritus, or it may be that the leading components of the Hawaiian forests which promptly invade fresh lava flows are gradually finding the older soils not to their liking.

The fact remains that we are confronted with the task of building up important watershed forests which are slackening in their vigor and we are attempting to do this by the infusion of new blood, by introducing foreign, tropical trees which will take hold strongly under the conditions where our native trees seem to be on the decline.

Species of the genus *Ficus* have been recommended for this purpose because of their vigorous and comparatively rapid and extensive growth and because of the facility with which their seeds may be dispersed by birds. In the past geological history of the Hawaiian

Islands, during the many upliftings and subsidences, the connecting continental bridge favoring plant migrations must have been broken during several eras. Although representatives of the fig family are found in Fiji, the Society Islands, and on Wallis Island, the Hawaiian group was left out and did not receive a single species.

With the advent of the early voyagers, many species of *Ficus* have been introduced into Hawaii for shade and ornamental purposes. The India rubber tree (*Ficus elastica*) familiar in New England as a bay-window pot plant, the Indian banyan (*Ficus bengalensis*), the Chinese banyan (*Ficus retusa*) and many others were brought as seedling plants or slips, set out in various parts of the Territory, and have grown to maturity without ever producing a single fertile seed.

Among the figs represented as large trees in Honolulu are two species from Australia which give great promise of usefulness in strengthening our watershed forests. These are the Moreton Bay fig (*Ficus macrophylla*) and the Port Jackson fig (*Ficus rubiginosa*). Although these had periodically produced large amounts of flower receptacles, resembling somewhat the edible fig but considerably smaller, no fertile seed had ever been set in them and the fruit fell from the trees before it came to maturity.

The reason for this was due to the fact that the wasp which is essential for the pollination of the blossoms in the receptacles had never been introduced. To make practical use of these trees, therefore, our efficient entomologists were called upon to secure the proper fig wasps required by these particular two species of trees to enable them to produce seed, in the same manner that before a single Smyrna fig could be brought to maturity and developed to edibility in California the pollinating insect had first to be secured.

The peculiar circumstance surrounding this relationship is that there is a mutual dependence between the wasp and the tree. Without the ceaseless aid of the wasp, the tree could not prolong its existence indefinitely because there would never be any fertile seed formed in its figs and it would ultimately perish with no seedling offspring to take its place. The fruit does not mature without the agency of the fig wasp. On the other hand, the wasp cannot develop or exist without the presence of the fig fruit in the proper condition for it. There is a very remarkable coordination in the development of both seed and wasp and the curious part of it is that each different species of tree has its own different species of fig wasp to assist it in seed production.

These wasps, by the way, are very small, and are more the size of an ant than like the wasp with which most of us are probably disastrously familiar.

The pollination brought about by the female wasp by the process which I shall soon describe does not appear to be due to superior intelligence on her part but to the unintentional result of her actions while searching selfishly for a place in which to rear her babies. Any one at all familiar with a fig fruit knows that its numerous flowers are situated on the inside of the receptacle. The only place that suits the female wasp's fancy for egg laying is within these flowers.

Besides the female flowers, there are others in which pollen grains are formed. These two kinds of flowers do not develop simultaneously in the same fig, so that it is necessary for a fig wasp to come from a different fig in a different stage of development to bring pollen to pollinate the female flowers before they can set or before a mature fruit can be produced. The male flowers, in which the pollen develops, are very immature in any given fig at the time the female flowers in the same fig are just ready to receive the pollen. The pollen can reach the female flower, at the time it requires it, only by the wasp, hatching from a ripe fig in which pollen has just been scattered from the male flowers, leaving the fruit with its body covered with pollen and immediately flying to and boring into a young fig containing female flowers just ready for the pollen. The female wasp is capable of extended flight and in the case of the fig wasp (*Pleistodontes imperialis*) attached to *Ficus rubiginosa* it is known to have flown against the wind for a mile and a quarter in seeking out another tree in Honolulu of the same species.

Let us see just what happens when the female wasp has a notion to lay eggs. She first sees the light of day by boring through the walls of a mature and ripened fig.

With uncanny craftiness she seeks out a fig in which the female flowers are just ready for the pollen. She enters through the natural opening at the apex of the fruit and places an egg in each flower she selects. While doing so, she crawls about and pollinates the other female flowers with pollen grains which were adhering to her body from the older fig where she herself had grown to maturity.

The eggs then hatch out and the young wasps grow to maturity. The fig at the same time has been developing and ripening both seeds and pollen flowers, so that when the mature wasp issues from the

mature fig which has changed, in the case of the Moreton Bay fig, from a light green to a yellowish and finally dark purple tinge, the male flowers have reached maturity, the pollen sacs are ruptured freely and a vast quantity of minute, white pollen grains, is scattered throughout the interior. Every wasp becomes covered with these fresh pollen grains which adhere to the insect and are carried to a younger fig as before. This new fig is in turn pollinated and the cycle is repeated.

This wonderful and complicated process of flower pollination for the production of seed in the Moreton Bay fig was actually carried by C. E. Pemberton from Sydney to Honolulu, a distance of 4,500 miles, and it is the first case on record where the fig wasp of a wild fig tree has been established outside of its natural habitat. He collected several hundred well-grown figs which were just reaching maturity and which contained large numbers of living pupae of the wasp *Pleistodontes froggati*. These were placed in the cool chamber of the S. S. "Ventura" at a temperature of about 45° F for the two weeks' voyage. The lot arrived in good condition and 2,000 living female wasps were liberated on February 9 and 10, 1921, in the two large Moreton Bay fig trees in Honolulu. The females were soon observed to enter young figs in their new home. On June 22, 1921, a little over four months later, figs from these trees were found to contain wasps, which evidently were of the second or third generation. Now the fruit on these trees no longer drops while still hard and immature. It takes on a larger size, assumes a dark color and becomes real soft before it is shed from the tree. Moreover, these fruits contain fertile seed from which thousands of young seedlings have already been raised and distributed throughout the Hawaiian Islands.

The fig pollinating wasp (*Pleistodontes imperialis*) on the Port Jackson fig tree (*Ficus rubiginosa*) was similarly transported from Australia in January, 1922. During the following July figs were collected and specimens of the wasp reared from them, indicating that it had become established in Honolulu. Instead of producing small, hard, green or yellow fruit which dropped from this tree in an immature state, it now, thanks to the wasp, sheds an abundant crop of larger, ruby red, soft figs which are full of fertile seed. No longer do we have to send away for fig seed of these two species and their spread by birds is now made possible by virtue of utilizing superior entomological knowledge.

GROWTH OF WHITE SPRUCE IN THE ADIRONDACKS[1]

By A. B. Recknagel

White spruce (*Picea glauca*) has a wider distribution in the Adirondacks than is commonly known. The species is found as a component of the spruce flat and swamp types in the Eastern and Central Adirondacks. Particularly is it found on the watershed of the upper Hudson (from Newcomb to Tahawus) and along the Cedar River near Indian Lake, N. Y. It has also been noted between Jay and Wilmington and along the road between Speculator and Wells in Hamilton County.

Last year opportunity came to make a study of the growth of white spruce in collaboration with Howard L. Churchill, T. H. Crawshaw, and P. K. Miller, of Finch, Pruyn and Company, and P. A. Herbert, then of Cornell University.

The study followed the method already described for red spruce and balsam in the Adirondacks.[2] A 10-inch Swedish increment borer was used; the borings were made at breast height, the diameter was determined by calipers and the heights by hypsometer. Altogether 279 trees were measured and inasmuch as the trees were bored to the core wherever possible, the total number of measurements secured was 868.

The computations of the field data were but recently completed. The first thing was to determine the average number of rings in the last inch of radius, by d. b. h. classes. The results are given in Table 1.

Next were computed the heights and from these, curved and tabulated, a local volume table in cubic feet was prepared, based on the table for spruce given in Cary's "Manual for Northern Woodsmen." These data are also given in the table herewith.

The current annual increment was computed by Pressler's well-known formula and the results, as given in the table, are harmonized by a curve.

[1] Paper read at the meeting of the New York Section of the Society of American Foresters, August, 1923.

[2] See Journal of Forestry, October, 1922.

TABLE 1.—*Diameter and Volume Growth of Adirondack White Spruce. (Based on 868 Measurements in Essex and Hamilton Counties, N. Y.)*

Diameter breast high (inches)	Total height (feet)	Volume (Cary, p. 239) cubic feet	No. of annual rings in last inch of radius (curved), per cent	Current annual increment per cent (Pressler) (curved), per cent
5	31	2.7	7.1	....
6	37	4.7	7.6	....
7	42	6.5	8.0	9.2
8	47	9.0	8.3	8.0
9	51	12.3	8.4	7.1
10	53	15.6	8.3	6.4
11	55	19.7	8.2	5.9
12	57	23.8	8.0	5.3
13	58	27.2	7.7	4.9
14	58	31.8	7.4	4.5
15	58	35.8	7.0	4.2
16	59	40.4	6.6	3.9
17	59	45.4	6.1	3.7
18	59	49.4	5.6	3.5

The values in the table indicate that, under identical conditions, white spruce grows more rapidly than does red spruce. Up to a diameter of 12 inches the growth is better than 5 per cent in volume yearly. The trees on which this study is based are for the most part forest grown.

It is safe to predict that white spruce will play an important part in the future of the Adirondacks. It is of equal quality with red spruce for paper pulp and is far better adapted to nursery practice and to planting. The rapidity of growth shown by this study is further evidence of its suitability for forest management.

TWENTY YEARS' GROWTH OF PLANTED NORWAY, JACK, SCOTCH, AND WHITE PINE IN NORTH CENTRAL MINNESOTA

By J. H. Allison

LOCATION

The plots furnishing the growth data herein recorded are located upon the grounds of the North Central (Agricultural) Experiment Station at Grand Rapids, Minn. This station is located about 20 miles east of the eastern boundary of the Cass Lake National Forest.

HISTORY

In the spring of 1897 Warren Pendergast, then superintendent of this station, purchased several thousand wild jack and Norway pine seedlings which had been dug in the woods near Carlton, Minn., a town near Duluth and about 75 miles southeast of Grand Rapids. These seedlings were placed in transplant rows upon the station grounds. The transplant rows were three feet apart and the seedlings were spaced six inches apart in the row. The Scotch and white pine stock was obtained from or through the U. S. Bureau of Forestry, the Scotch pine in 1897 and the white pine (2-2 stock) in 1898. These species were placed in transplant rows along side of the wild Norway and jack pine. All four species remained in these transplant rows until planted on the present site in 1900 and 1901.

In 1899 Prof. H. H. Chapman, who had become superintendent of this station, decided to use this stock, which was in the transplant beds already mentioned, to determine for North Central Minnesota (*a*) the relative value, for planting purposes, of these four species, namely, Norway, Scotch, jack, and white pine; (*b*) whether they should be planted in pure or mixed stands; and (*c*) the spacing which should be used in field plantations. During that year he set aside a 32-acre tract of rough, stony, cut-over station land as an experimental area and divided it into acre plots. This tract had been formerly, and parts of it still were, covered with a fair stand of Norway pine, mixed in with which were a few jack pines. Ten of

these plots were planted in 1900 and four more in 1901, using 4 by 4, 6 by 6, 8 by 8, and 10 by 10 feet spacings for pure Norway and white pine plantations and a 6 by 6 foot spacing for mixed "Norway-white-jack pine" and "Norway-Scotch pine" plantations. Just before the 1900 planting operation was undertaken, the entire area was burned over, some parts of it being severly burned, other parts burning hardly at all. No other preparatory site clearing operations were undertaken. The plots selected for planting were practically free from debris, brush or timber cover.

The actual planting operation was carried on during the latter part of April. The stock must have been large—although its size was not recorded, except for the Scotch pine which averaged about 17 inches high. The trees were dug out of the transplant rows with a spade, laid on the ground and left there with their roots covered with earth until needed at the planting site to which they were hauled in a wagon box, roots down, tops up, after having been thoroughly wet down. Upon arrival at the planting site they remained in the wagon box until needed, the time varying from a few minutes to over night. Bushel baskets were used in distributing the trees to the planters. Spades were used in planting. The sod was cut and turned back, a spade full of earth was removed, the tree inserted, the earth replaced and trampled down, and the sod turned back. The weather was quite hot and dry during the 1900 planting period, and no rains fell before or during the operation. The frost was not yet entirely out of the ground. No record of the weather conditions was made at the time of the 1901 planting operation.

Reduced to an acre basis, the 1900 6 by 6 foot plots cost $3.94 per acre for planting work and $1.66 per acre for digging, the trees and hauling them three-fourths of a mile from the transplant bed to the planting area making a total cost, in 1900, of $5.60 per acre for the work done that year. Similar work in 1901, cost $8.85 per acre, but only about 2,000 trees were planted in 1901 as against 13,000 in 1900. Neither the original cost of the planting stock nor the cost of caring for it while in the transplant beds is included because these costs have not been recorded.

In the spring of 1905 a fire swept over all of these plots, killing practically all of the trees set 4 by 4 feet, 8 by 8 feet, and 10 by 10 feet, and severely damaging the 6 by 6 foot plots. Beginning with and

continuing since 1905 the entire area within which these plots are located has been used as pasture.

In 1915 I heard of these plantings and determined to use them, if possible, for the purpose of securing growth data. Upon looking them up, it became apparent that none of the original plots could be used as originally laid out—due to the extensive blanks caused by the 1905 fire. Furthermore at that time I was unable to determine the dimensions and location of the original plots. Considering the stands as they then stood, I decided to lay out, within the boundaries of certain of the original plots, seven small plots, three in the pure Norway, two in the pure white pine, and one each in the mixed Norway-Scotch pine and Norway-white-jack pine stands. These plots were laid out and measured in December, 1915, and again in November, 1920.

DESCRIPTION OF MY 1915 PLOTS

Plot I.—Scotch and Norway Pine.—Within the north part of original plot 16. It covers an area of 0.25 acres (net 0.15 acres). It was practically free from brush and debris at the time of planting. The north half of the plot is pure Scotch pine; the south half Scotch and Norway pine in alternate rows, planted 6 by 6 feet in 1900. The Scotch pine was from 14 to 20 inches high at the time of planting. Alder and hazel brush has come into the openings caused by the 1905 fire.

Plot II.—Norway Pine.—Located in the south half of original plot 16. It has an area of 0.25 acres (net 0.16 acres). Planted 6 by 6 feet in 1900. Brush is coming into the blanks in this stand.

Plot III.—Jack and Norway Pine.—Part of original plot 117, planted 6 by 6, in 1900. It has an area of 0.40 acres (net 0.28 acres). The Norway and jack pine was planted in alternate rows. The white pine, which replaced the Norway pine in the southern part of this plot, has almost entirely disappeared, probably due to the fire of 1905. Hazel and alder brush has occupied the blanks in this stand.

Plots IV and VI.—Norway Pine.—Both located within original plot 115. Total area 0.78 acres (net 0.66 acres). Planted 6 by 6 feet in 1900. No brush or debris on these plots at the time of planting. Very little brush on them now.

Plot V.—White Pine.—Part of original plot 114, planted 6 by 6 feet in 1900. It has an area of 0.27 acres (net 0.23 acres). It includes the best body of white pine on the original plot. There were a few jack pine seedlings, but no brush or debris on this plot at the time of planting. The jack pines have persisted. There is very little brush now on this plot.

Plot VII.—White Pine.—Part of original plot 1114, planted 6 by 6 feet, in April, 1901. This plot covers 0.57 acres (net 0.28 acres). Over half of the trees, even in the best parts of the original plots, have died and disappeared, due largely to the fire of 1905. The blank portions of the area are being rapidly occupied by jack pine.

The period (1916-1920) during which these plots have been under observation has been one of local drought, the average annual precipitation for this period being 22.15 inches as against the 33 year average of 27.38 inches, while that received during the growing season (May 1 to Aug. 31) average 12.16 inches as against 15.47 inches for the 33-year average. One year, 1917, was particularly dry, the total precipitation amounting to only 14.71 inches, and that received during the growing season to only 6.32 inches. Otherwise climatic conditions do not seem to have varied much from average, except that the summer of 1919 produced a few unusually hot days.

The trees within the plots selected in 1915 have been growing rapidly, especially during the last five years in spite of drought and grazing. The trees on these plots do not differ appreciably in size or vigor from those growing upon the remaining parts of the original plots.

SUMMARY

Norway Pine.—This species stood the fire of 1905 better than either one of the other three species. In mixture with Scotch and jack pine, it at first fell behind these species in diameter and height growth, but it is now approximately holding its own with the jack pine and is gaining over the Scotch pine. In pure stands this species is not growing quite as fast, in either height or diameter, as it is in mixture, but on the other hand the pure stands are very much denser (average 640 trees per acre) than are the mixed stands (total of 307 trees per acre for the jack-Norway mixture and 507 trees for the Scotch-Norway mixture). In volume, this species, in pure stands, has been producing woods at an average rate of about 0.6 cords per acre since these

plantations were established. During the last five years, however, it has been producing wood at the rate of about 1.36 cords per acre per year. This growth has been made in spite of the fact that the last five years have been years of drought. If the dominant trees continue to grow during the next ten years at the same rate that they have during the last five, they should reach, at 31 years of age, a breast height diameter of about ten inches and a height of 45 feet. Judging from general appearance, the pure Norway stands should be thinned within the next ten years, probably within five years.

Jack Pine.—In mixture with Norway pine. The individual jack pines are now larger, in both diameter and height, than any of the other species. In ten years more (31 years after planting) the dominant ones should reach approximately 11 inches in diameter breast high and 45 to 50 feet in height. But the number of trees per acre is small, there being only 307 including the Norways in the mixture. The annual wood production of these 307 trees, however, is only slightly less than that of the pure Norway stands (average 640 trees per acre). The reduction of the number of trees from about 1200 to the acre to 307 to the acre was mainly brought about by the fire of 1905. Apparently a wider spacing than 6 by 6 feet, say 8 by 8 feet or 10 by 10 feet, would work very well, as far as volume production is concerned with jack pine or jack and Norway pine mixture.

Scotch Pine.—In mixture with Norway pine. This species started off more vigorously than either of the other three species, but during the last five years all of the other species have gained on it. The jack pine has now passed it in both breast high diameter and total height, while the Norway pine has caught up with it in height and is gaining on it in breast diameter. It has developed poor form, however, and is very much more crooked than the other species. In addition, it is being vigorously attacked by sap suckers.

White Pine.—This species was very severely damaged by the 1905 fire. Apparently the pasturing of the tract also has injured it. Furthermore, the white pine weevil has attacked most of the trees, causing them to develop a very brushy, squatty form. In 1915 this species appeared to be in distinctly poor health. It is now in vigorous health. During the last five years it has grown well, both in diameter and height.

GENERAL CONCLUSIONS

The soil under these plots has not been carefully examined. Dr. F. J. Alway, Chief of the Division of Soils at the Agricultural Experiment Station, who is familiar with this tract, states that it is "second-rate agricultural land" and that it seems to have "a sandy loam surface with a subsoil of the same character or somewhat coarser, carrying many boulders and cobblestones." The ground was originally occupied by a fair stand of Norway pine. Apparently the soil is a fair Norway or a good jack pine soil. Jack pine is seeding in on it very vigorously.

These plantations indicate, 21 years after planting, that Norway and jack pine are the species best suited to rather poor soils under local climatic conditions; that these species may be used alone or in mixture; that they will grow vigorously even during the periods of drought; that they may be depended upon to produce a mean annual growth for periods of 40 or 50 years of at least three-fourths of a cord of wood per acre per year, and in all probability of a cord or slightly more per acre per year; that these species should be so planted or thinned that there would be, in pure stands, about 300 to 400 jack pines or 500 to 600 Norway pines per acre at the end of 20 years; that Scotch pine should not be planted, except experimentally; and that no definite conclusions can yet be drawn with reference to white pine.

CURRENT GROWTH IN NORWAY PINE

By T. Schantz Hansen

Lake States Forest Experiment Station, Cloquet, Minnesota.

The plot on which this article is based was established in 1912 as one of a series of thinning plots at the Cloquet Forest Experiment Station. It was the only plot of the series located in a Norway pine stand. No thinning was done, other than that which took place naturally. Thus having measured the plot for the third time in 1922, it is possible to give a few indications about the growth of fairly young Norway pine stands.

The stand of which the plot is a part is a mixture of Norway pine and jack pine. There is very little underbrush present and no reproduction except in the openings. There is a good layer of humus covered by a heavy coat of needles and other litter which does not decay rapidly. The ground cover consists principally of blueberry, sweet fern, honeysuckle, and wintergreen. The soil is sandy and grades off into a rather coarse gravel. It lies in the surface formation classed as outwash gravel.

As is typical of this region, the stand has been subjected to a number of fires so all the trees are more or less cat-faced. These scars show three fires all coming from the same direction. While these fires doubtless have had some effect on the rate of growth it must be remembered that it is common to all stands of like age in this region.

When the plot was established in 1912, the average age of the Norway pine was 88 years and of the jack pine 86 years. This would place it in a very thrifty stage for Norway pine. Yield tables for Norway given in U. S. D. A. Bulletin 139 show the culmination of mean annual growth at 130 years regardless of site, while the current annual growth culminates at 110 years. There are no normal yield tables available for jack pine, but it is known that the growth culminates at a rather early age so the jack pine can be expected to be on the decline.

The plot covered an area of two acres. At the time of installation there were 234 trees on the plot, 140 or 59 per cent were Norway pine, 91 or 39 per cent were jack pine, and 3 or 2 per cent were white pine. It is not entirely typical of the region to find so heavy a mixture of jack pine in such an old stand of Norway pine, but it is not an unusual occur-

rence especially on the more sandy sites. In 1917 there were 206 trees on the plot, or a loss of 11 per cent; 137 or 66 per cent were Norway pine, 66 or 32 per cent were jack pine, and 3 or 2 per cent were white pine. Thus five years after establishment we can see there is a heavy loss in jack pine. In 1922 there were 192 trees showing a loss of 6 per cent from the stand in 1917; 136 or 70 per cent of these were Norway pine, 53 or 28 per cent were jack pine, and 2 per cent were white pine. In the ten-year period the proportion of Norway pine increased 4 per cent in the stand due to the heavy death in the jack pine. The loss in jack pine was caused through windbreak and rot. Very often the tree would become so weakened as to break before the rot entirely killed it. The heart rot infesting the pine appeared to be *Trametes pini*. The remaining jack pines are not in a thrifty or healthy condition, so the loss will probably be heavier during the next five-year period.

Table 1 gives the d. b. h. and the total height of the average tree for the different periods.

TABLE 1.—*D. b. h. and Height of Average Tree.*

Species	D. b. h. (inches)			Total height (feet)		
	1912	1917	1922	1912	1917	1922
Norway pine	13.9	14.8	15.2	68	72	70
Jack pine	12.4	13.1	13.3	66	73	76
White pine	16.7	17.7	18.2	69	79	74

The diameter of the average tree was computed from the average basal area. Measurement was made at the same point on the stem for the three successive measurements. The average tree shows a marked increase in diameter for the first five-year period with an increase less than half as much for the following five-year period. This can hardly be accounted for by virtue of the stand reaching maturity. The loss of 28 trees in a period of 10 years should have stimulated the remaining trees considerably.

The height of the average tree as given in the table is not the height of the tree of that diameter, but it is an average of all heights. Many discrepancies were noted in the height measurements taken at different periods. Heights were all taken with a Forest Service standard hypsometer. The probable reason for the difference in readings

is the choice of point of measurement and the angle from which the tree is measured. Few trees are exactly perpendicular so the angle from which measured would affect the height reading considerably. This error would tend to be compensating through the entire plot. In a stand of this age not much increase in height would be expected.

Volumes were compiled using Tables 19 and 21 in U. S. D. A. Bulletin 139, Norway Pine in the Lake States, and Tables 24 to 25 in U. S. D. A. Bulletin 820, Jack Pine. Table 2 gives the volume of the Norway pine and jack pine at the time of the three measurements. The white pine was not considered because of its small numbers.

TABLE 2.—*Volume of Norway Pine and Jack Pine Expressed in Board Feet and Cubic Feet.*

Year	Norway pine		Jack pine	
	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.
1912...........	20,973	5,253.6	8,985	2,445.6
1917...........	25,561	6,173.4	8,252	2,223.8
1922...........	26,681	6,402.5	6,815	1,760.9

If we express the rate of increase in per cent we have the results shown in Table 3.

TABLE 3.—*Rate of Growth Based on Table 2.*

Year	Norway pine				Jack pine			
	Bd. ft.	Per cent	Cu. ft.	Per cent	Bd. ft.	Per cent	Cu. ft.	Per cent
1917..........	4,688	22.3	919.8	17.5	733	8.1	221.8	9.7
1922..........	1,120	4.3	229.1	3.7	1,437	17.4	462.9	20.8

Norway pine lost through windfall 266 board feet or 72.4 cubic feet during the period of 1912-17 and only 160 board feet or 39 cubic feet from 1917-22. This would indicate that the stand is thrifty and sound.

Jack pine tells a different story. During the five-year period of 1912-17 there was a loss through windfall, windbreak, and death of 2,853 board feet or 839 cubic feet. The period of 1917 to 1922 showed a loss of 1,546 broad feet or 385.2 cubic feet. Jack pine in this stand is truly decadent. The wisest practice to follow would be the complete removal of jack pine from stands of this character before they reach this stage.

TABLE 4.—*Precipitation at Cloquet by Months—1912 to 1922, Inclusive.*

Month	First period							Second period						
	1913	1914	1915	1916	1917	Total	Monthly average	1918	1919	1920	1921	1922	Total	Monthly average
January	.73	1.57	2.96	4.10	.98	9.44	1.89	.96	.46	1.87	.57	.78	4.66	.93
February	.83	1.40	1.63	.53	.97	5.36	1.07	.31	.94	.75	.58	4.45	7.03	1.40
March	2.47	.75	.36	2.91	2.79	9.28	1.85	.52	1.16	2.09	1.25	2.61	7.63	1.42
April	1.91	2.20	.97	4.25	1.11	10.44	2.11	1.49	1.82	1.81	1.80	2.47	9.39	1.88
May	5.46	2.54	3.72	3.96	.41	16.09	3.21	3.80	1.72	5.66	3.50	3.51	18.19	3.64
June	3.53	6.80	5.15	6.82	2.54	24.84	4.99	1.40	4.80	5.96	4.08	3.78	20.02	4.04
July	6.93	1.78	1.34	1.64	5.23	16.90	3.40	1.78	3.11	3.10	3.62	2.16	13.77	2.75
August	1.65	4.47	1.72	4.11	2.47	14.42	2.88	2.28	3.77	1.33	1.91	1.75	11.04	2.20
September	3.62	3.02	1.75	2.83	2.59	13.81	2.76	2.54	1.51	2.02	2.58	2.84	11.49	2.29
October	3.12	1.14	3.17	1.75	2.81	11.00	2.39	2.42	3.24	2.97	.88	.85	10.36	2.07
November	.76	.93	2.48	.08	.13	4.38	.87	2.45	4.29	1.88	.94	3.97	13.53	2.70
December	2.50	.30	1.10	.47	1.41	5.78	1.15	2.04	.24	1.07	1.90	1.48	6.73	1.34
Total	33.51	26.90	25.43	33.45	23.44	142.73	......	22.01	27.06	30.51	23.61	30.65	133.84	......
Monthly average	2.89	2.23	2.12	2.79	1.95	2.37	......	1.83	2.25	2.54	1.97	2.55	2.23	......

There is a falling off in rate of growth which can not be explained by virtue of the stand having reached maturity. All work done previously indicates that current growth Norway pine does not culminate until the stand is 110 years old. This stand is now 98 years old. Moreover the change in rate due to maturity would be gradual rather than abrupt. There evidently was some external factor at work.

The factor which seems to influence growth markedly is the rainfall the stand receives. Table 4 gives the rainfall by months for the two periods. The total yearly precipitation and the average monthly precipitation is given as well as the total precipitation for the various months over the entire period and the average.

We find that when we consider total precipitation there is very little difference in the two periods. The second period received a total of 8.89 inches less rainfall than did the first. This is not a very large difference considering the fact that it occurred over a period of five years. In each period we find two years with a total precipitation below the average, one year average, and two above average.

If we confine ourselves to the growing period of the five months, April to August, inclusive, we find that the second period received 10.10 inches less rainfall in the growing seasons than did the first. The average rainfall for the season in the first period being 16.59 inches and in the second period 14.51, a difference of 2.08 inches, or very nearly an average month's rainfall. This difference in precipitation probably accounts for some difference in the rate of growth. The year 1917 was much below normal in precipitation as was the year 1918. The last year of the first period and the first year of the second being dry would doubtless have a tendency to retard the rate of growth. These are but suppositions which the next measurement will have to bear out.

Summing it all up, then, this plot shows the Norway pine to have been in a thrifty stage five years ago, and while it did not show a corresponding increase during the second period, it was not deteriorating. Jack pine in the stand is shown to be decadent with a heavy loss in volume, indicating its removal at much earlier age.

THE IMPORTANCE OF DUFF MOISTURE CONTENT IN THE FOREST FIRE PROBLEM [1]

By H. T. Gisborne,
Priest River Forest Experiment Station

The fire season of 1919 is recognized today as being the most dangerous of all seasons since active forest protection began to be applied in northern Idaho. Among the men who were in charge of fire fighting organizations at that time the consensus of opinion is that very few individuals recognized the symptoms of approaching danger until extreme dryness and an epidemic of forest fires taxed the strength of the protective organization to the utmost. There was no method available then for obtaining measuremnnts of existing dryness to serve as a check on observation and experience. The same conditions resulted in extremely large fire losses in western Washington early in 1922. It is obvious that there is a great need for some sort of measurement which will serve as an index of existing and approaching fire danger.

Most investigative work concerned with forest fire conditions has, in the past, endeavored to use some simple element of the weather as an index of prevailing inflammability. We know that the weather controls inflammability by controlling the amount of moisture in the various fuels that burn in a forest fire, consequently weather records seemed to offer a means of providing the desired index. It is apparent, however, that complete weather records contain such a multitude of combinations of the various factors which compose the weather that any consistently accurate deductions of the effect on inflammability are extremely difficult. Records of rainfall alone probably have been used more than any other simple measurement as an indicator of wetness of fuels, but such records have been insufficient because they failed to consider the varying degrees of atmospheric drying power between periods of precipitation. Vapor pressure, relative humidity, and evaporation records have also been used and while they undoubtedly add to our knowledge of the situation they, in turn, fail to allow

[1] Presented at annual meeting of the Society at Baltimore, Md., December 28, 1923.

for the full effect of precipitation. It is evident that all of the components of the weather must be given proper consideration, yet from experience we have found that complete weather records are both difficult to obtain and overwhelmingly impractical in their application.

At the Priest River Forest Experiment Station in northern Idaho we are studying all of the factors which affect inflammability in the forests. We are endeavoring to obtain a simple measurement which will serve to indicate the prevailing degree of inflammability. Acting on the results of previous researches by Show in California and Larsen at Priest River, we have obtained considerable data on the moisture contents of the important forest fire fuels throughout the last two fire seasons.

Light fuels such as fine hair moss and the dead leaves of herbs and shrubs seem to show the effect of the weather for only 12 to 24 hours preceding the time of measurement. Small twigs supported in the air will hold their moisture longer than moss and will require more atmospheric moisture to increase their wetness appreciably. The top quarter to half-inch layer of duff responds even more slowly to changes in the weather yet much faster than heavy slash or the outside half-inch of windfallen trees. The full layer of duff is still more sluggish in its responses, and the inside wood of windfalls may have a hang-over moisture content in proportion to weather conditions which prevailed several months previous to the date of measurement. Rain, hail, snow, temperature, humidity, wind velocity, sunshine, soil moisture, exposure, and slope have all exerted varying influences on the moisture content, consequently the inflammability, of some or all of these forest fire fuels, hence if we measure their respective moisture contents we have the resultant effect of all the influences.

The technique of measuring the amount of moisture in each of these fuels so that results can be plotted every day and at different hours in any one day has not yet been developed, however. Furthermore, these fuels, mentioned above, are not of equal importance. Light moss and dead weeds may be dry enough to be ignited with a match, yet if twigs, duff, and branchwood are too wet to burn there is no serious fire danger prevailing. Our burning tests to determine inflammability according to amount of moisture in the materials have shown these conditions repeatedly in the white pine type of northern Idaho.

The term "forest fire" as commonly used in northern Idaho includes any fire in or near the forest, whether the principal fuels are weeds

and grass, slash and logging equipment, or duff, windfalls and green timber. The principal fuel may vary considerably, however, and this variation must certainly be taken into account when measurements are made to determine the prevailing degree of inflammability or the probable danger. In the western white pine timber type fire cannot spread far except through duff, dead branchwood, and windfalls, unless an exceptional wind velocity and a very dry atmosphere prevail. Crown fires occur, but they are exceedingly rare when the duff, dead branchwood, and windfalls are too wet to burn. The average fire, which causes the greatest expense and loss, runs through these three principal fuels before it rises to a crown fire and a conflagration.

Our field measurements and laboratory tests covering the last two fire seasons show that the top quarter to half-inch layer of duff is sufficiently responsive to weather changes so that it can be used to provide a warning of impending inflammability in advance of the drying out of the heavier materials, yet it is not as radical and alarming in its fluctuations as the finer fuels such as moss and dead weeds. As a criterion of inflammability of the materials which compose the bulk of fuels for a white pine timber type fire, the top layer of duff seems to satisfy our requirements.

Two other conditions also weigh in favor of top layer duff as an indicator of average inflammability in the white pine timber type of northern Idaho. By far the greatest proportion of surface area is covered by duff; more wind-blown embers and sparks will come to rest on the duff than on any other material except the green tree canopy; if this top layer of duff is non-inflammable these sparks will not spread into spot fires and the advancing flames of the main fire itself will be stifled or impeded by the moisture in the duff surface. The amount of moisture in the top layer duff, and the corresponding degrees of inflammability, are comparatively easy to determine.

To summarize: In the most valuable timber type in northern Idaho the top quarter to half-inch layer of duff exhibits the effects of all the weather elements as they affect dryness and inflammability in the forest. Top layer duff picks up or loses moisture about as the average important fuel in this type, and is in itself one of the most important receivers and carriers of fire. The prevailing moisture content and the corresponding degree of inflammability of top layer duff are easy to determine.

HIGH TEMPERATURES AS A REMEDY FOR LYCTUS POWDER-POST BEETLES

By T. E. Snyder

Entomologist, Bureau of Entomology, U. S. Department of Agriculture

Lyctus powder-post beetles cause extensive losses to the seasoned sapwood of hardwood lumber, implement handles, furniture, etc., especially ash, hickory and oak. Damage of this type is distributed widely throughout the world, many species of these beetles being carried from one country to another in the commercial products which they infest.

The winged adult beetles lay their eggs in the pores of the wood and the larvae or grubs burrow through the wood and reduce the fiber to a flour-like powder. The different kinds of Lyctus beetles vary somewhat in their habits and seasonal history, but there is a general similarity. They pass the winter as larvae in the wood, change to the resting stage or pupae in the early spring, and during late spring and early summer the adult beetles emerge from the wood and fly about. Under natural out-of-door conditions the eggs are laid in the pores of the woods soon after activity commences in the spring, but in storehouses, sheds or buildings kept warm and dry, the development may take place and the eggs may be deposited much earlier.

Recent tests have demonstrated that kiln drying at high temperatures will kill the larvae of Lyctus powder-post beetles in infested wood. Kiln drying may be necessary when the more practical methods of prevention have not been carried out. Unlike, in the case of the red-headed ash borer, kiln drying will *not* render the wood immune to subsequent attack by Lyctus powder-post beetles and the same precautions have to be taken as in ordinary air seasoned stock. These precautions, as well as simple remedies, will be briefly outlined before discussing the kiln drying tests.

Damage and losses by Lyctus powder-post beetles to the sapwood of seasoned hardwood stock can be prevented by the adoption of a system of periodical inspection, classification by species and sapwood and heartwood stock, and the utilization of the older stock first.

Submergence of sapwood material in water for periods of four months or longer leaches out or changes the food values in the cells, rendering the wood unfavorable and not liable to subsequent attack.

Since the beetles lay their eggs in the pores of the wood, any substance which closes the pores of the wood may be effectively applied. Two coats of boiled linseed oil applied hot, varnish, shellac, paraffin wax, a mixture of resin and lampblack, or other fillers effectively close the pores and prevent oviposition.

The heartwood is immune to attack by Lyctus powder-post beetles and should be used wherever possible.

Simple remedies to use in case of small quantities of stock are trimming off and burning infested sapwood edges. Dipping in or spraying infested stock with orthodichlorobenzene will kill the larvae in the wood.

The heat generated during the ordinary dry kiln operation is sufficient to kill certain borers infesting wood. Experiments by Dr. F. C. Craighead [1] have shown that the larvae of the red-headed ash borer (*Neoclytus erythrocephalus* Fab.) can be killed in any kiln process which can be considered practical for the seasoning of ash, regardless of the thickness. Such treatment will also prevent further attack by the red-headed ash borer.

In the case of Lyctus powder-post beetles, however, the temperatures of the ordinary kiln process are not fatal to the larvae. Recent preliminary experiments conducted with the U. S. Navy Department have shown that higher temperatures are necessary and that subjecting seasoned wood to temperatures of 180° F. in dry kilns is an effective remedy. In order to kill the larvae in infested wood, it is necessary to run the infested material through the ordinary process and at the end of this operation have the temperature raised to 180° F. or over for a short period—one-half hour or longer depending on the dimensions of the material,[2] or rather of the sapwood. According to the Forest Products Laboratory, under ordinary circumstances the mechanical properties of the wood will not be appreciably impaired by a temperature of 180° F. maintained for an hour. The humidity should be such

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[1]Craighead, F. C., and Lougborough, W. K. Temperatures Fatal to Larvae of the Red-headed Ash Borer as Applicable to Commercial Kiln Drying. Jour. of Forestry, Vol. 19, No. 3, pp. 250-4, March, 1921.

[2]Tabulated statements giving details of experiments conducted in cooperation with the U. S. Navy Department is appended; these tests were conducted in California.

as to prevent a change in moisture content. Such severe treatments have been used upon 5 by 7 wagon bolsters without deleterious effect upon the strength and the Forest Products Laboratory frequently recommends in the interests of good drying that the stock be given a preliminary steaming or high humidity treatment of temperatures considerably in excess of the initial drying temperatures.

It must be remembered that this treatment is only a *remedy* and will *not* prevent later attack by Lyctus powder-post beetles and the kiln-dried stock must be periodically inspected and rapidly utilized or treated with linseed oil, varnish, etc., to close the pores of the wood.

More complete and thorough kiln drying and steaming tests of infested material of different dimensions are to be made in the near future at the Philadelphia Navy Yard.

HIGH TEMPERATURE KILN-DRYING TREATMENTS

14,546 feet white ash, infested with the powder-post beetle, was treated at the dry kiln at the U. S. Navy Yard, Mare Island, Calif. The heat treatment was started at 2 p. m., June 14, 1921, and was maintained throughout the day and night until 12 o'clock noon, Saturday, June 18.

TEMPERATURE MAINTAINED IN DRY KILN

Started heat 2 p. m., June 14. 1921.

3:00 p. m.	95°
5:00 p. m.	100°

June 15, 1921		June 17, 1921	
8:00 a. m.	100°	8:00 a. m.	146°
10:00 a. m.	110°	10:00 a. m.	148°
12:00 m.	120°	12:00 m.	148°
3:00 p. m.	125°	3:00 p. m.	148°
5:00 p. m.	130°	5:00 p. m.	148°
June 16, 1921		**June 18, 1921**	
8:00 a. m.	135°	8:00 a. m.	148°
10:00 a. m.	137°	9:00 a. m.	162°
12:00 m.	142°	10:00 a. m.	166°
3:00 p. m.	142°	10:30 a. m.	170°
5:00 p. m.	146°	11:30 a. m.	180°
		12:00 m.	182°

The above material was removed from the dry kiln June 21 and delivered on a flat car to be placed in quarantine.

HIGH TEMPERATURE KILN-DRYING TREATMENTS

Approximately 10,401 feet ash, white, No. 1 common, 3-inch, was treated at the U. S. Navy Yard, Mare Island, Calif., in the dry kiln with a view of exterminating the powder-post beetle. The heat treatment was started at 3 p. m., June 22, and was maintained throughout the day and night until the afternoon of June 27 as indicated below:

TEMPERATURE MAINTAINED IN DRY KILN

Started heat 1:00 p. m., June 22, 1921

3:00 p. m. 100°
4:55 p. m. 110°

June 23, 1921

8:00 a. m. 135°
10:00 a. m. 140°
12:00 m. 140°
3:00 p. m. 142°
4:55 p. m. 142°

June 24, 1921

8:00 a. m. 148°
10:00 a. m. 149°
12:00 m. 142°
2:00 p. m. 142°
4:00 p. m. 141°
4:55 p. m. 141°

June 25, 1921

8:00 a. m. 132°
10:00 a. m. 131°
11:50 a. m. 132°
Afternoon 140°

June 26, 1921

142° all day Sunday.

June 27, 1921

8:00 a. m. 142°
10:00 a. m. 160°
12:00 m. 172°
3:00 p. m. 180°
4:55 p. m. 182°

The above material was removed from the dry kiln and loaded on a flat car ready to be placed in quarantine.

HIGH TEMPERATURE KILN-DRYING TREATMENTS

Approximately 16,141 feet of 1½-inch ash was treated at the U. S. Navy Yard, Mare Island, Calif., in the dry kiln with a view of exterminating the powder-post beetle. The heat treatment was started Saturday, July 16, 1921, and maintained throughout the day and night until 5 p. m., July 22, as indicated below:

TEMPERATURE MAINTAINED IN DRY KILN

Started heat Saturday, July 16.

10:00 a. m. 100°
12:00 m. 140°
Afternoon and night 140°

July 17, 1921, Sunday

9:30 a. m.	115°
12:30 m.	110°
4:30 p. m.	110°
8:30 p. m.	102°
9:00 p. m.	102°

July 18, 1921

8:00 a. m.	110°
10:00 a. m.	125°
12:00 m.	134°
2:00 p. m.	138°
4:00 p. m.	140°

July 19, 1921

8:00 a. m.	140°
10:00 a. m.	146°
12:00 m.	148°
2:00 p. m.	150°
4:00 p. m.	150°
5:00 p. m.	150°

July 20, 1921

8:00 a. m.	160°
10:00 a. m.	150°
12:00 m.	154°
2:00 p. m.	154°
4:00 p. m.	156°
5:00 p. m.	156°

July 21, 1921

8:00 a. m.	156°
10:00 a. m.	156°
12:00 m.	156°
2:00 p. m.	156°
4:00 p. m.	156°
5:00 p. m.	156°

July 22, 1921

8:00 a. m.	156°
9:00 a. m.	160°
10:00 a. m.	162°
11:00 a. m.	164°
12:00 m.	168°
1:00 p. m.	170°
2:00 p. m.	174°
3:00 p. m.	176°
4:00 p. m.	180°
5:00 p. m.	180°

The above material was removed from the dry kiln and loaded on a flat car ready to be placed in quarantine for observation.

RELATIVE SUSCEPTIBILITY OF INCENSE CEDAR AND YELLOW PINE TO BOLE INJURY IN FOREST FIRES

By Harry G. Lachmund

Junior Pathologist, Office of Investigations in Forest Pathology, Bureau of Plant Industry, San Francisco, Calif.

In the year 1921 the writer presented data[1] from studies in the mixed coniferous forests in California indicating that incense cedar suffered much heavier bole injury than any of its associates. More recent investigations[2] have confirmed this relation and have provided a better basis for judging the relative damage by fire to incense cedar and yellow pine. The studies were conducted in 1921 in a section of the Modoc National Forest, California, burned over in a typical ground fire in 1920. The region is a tableland of volcanic origin at an elevation of about 5,000 feet. The virgin stand consists for the most part of yellow pine, mixed in varying percentages with intense cedar. White fir, sugar pine, and Douglas fir are scattered through the forest in small numbers. The stand is mature and runs about 17,000 feet board measure to the acre. Reproduction is heavy in general, and ranges from 8 to 20 feet in height.

There is sufficient evidence to show that ground fires have been frequent in the past throughout the region but that no fire of any consequence has occurred for a considerable number of years prior to 1920. In general the damage resulting from fire over the burnt region is moderate.

The following study is based on 141 yellow pines and 45 incense cedars of 6.5 inches d. b. h. and over two plots aggregating about 5½ acres.

Despite the fact that the representation of yellow pine is about three times that of incense cedar a total of 67 old scars formed in fires previous to 1920 is almost equally divided between the two species. About half of the old scars on either species are of a serious nature. With few exceptions all are still open, and in every case the old open wounds had become enlarged by the 1920 fire through killing of the living tissues surrounding the old scar. The relative severity of exten-

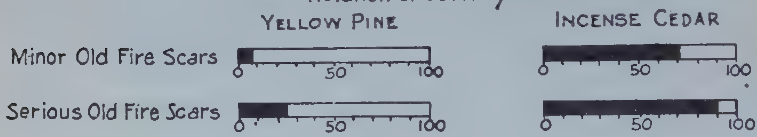
[1] Lachmund, H. G. Some Phases in the Formation of Fire Scars. Journ. For., Vol. XIX, No. 6, p. 638. 1921.

[2] Lachmund, H. G. Bole Injury in Forest Fires. (Submitted for publication.)

sions of old scars is graphically given in Figure 1. The graph shows that both minor and serious old scars on incense cedar are much more liable to heavy extension than those on yellow pine.

The ratio of distribution of new lesions caused by the 1920 fire over number of yellow pines and incense cedars is more in keeping with the representation of both species than is the case for old scars. 204 new lesions were found on the 141 yellow pines against 78 on the 45 incense cedars. It should be noted, however, that of the new scars only 6 per cent were serious on yellow pine again 36 per cent on incense cedar. The relative liability of the two species to bole injury from fire becomes even more evident when they are compared by numbers of individual trees wounded.

Fig. 1 Comparison of Yellow Pine and Incense Cedar. Relation of severity of extensions to old fire scars.



The percentages of old scars with serious and minor extensions are represented in black and white respectively.

Incense cedar was found to have not only a higher percentage of its trees fire-scarred with 87 per cent against 69 for yellow pine but has suffered much the heaviest damage from all types of fire injury to the bole. It has 33 per cent of its trees seriously scarred in previous fires, against 12 per cent for yellow pine. 36 per cent of incense cedar have serious 1920 extensions to old fire scars against 3.5 per cent for yellow pine. 42 per cent of the incense cedar have serious new lesions against 9 per cent for yellow pine. In other words, incense cedar has suffered much heavier injury throughout, in fires past and present.

Differences in the structure and composition of wood and bark of the two species are, without doubt, largely responsible for such relationships.[3] In addition it seems that insects take an important part in causing the heavy damage suffered by incense cedar. The most common observed in the present study was a round-headed borer, presumably *Hylotrupes amethystinus* which was found present under the dead back coverings of practically all of the heavier injuries and of many of the smaller ones. In many instances it appeared that the borers were

[3] See footnote 1.

not confining their activities to the killed area of cambium alone but were destroying the living cambium bordering the injury. In ten cases it was possible to ascertain beyond doubt that borers were responsible for considerable enlargement of the area of the fire scar. Although insects of various types were commonly found working under the dead bark covering the injury no similar enlargements of fire scars from this source were observed in yellow pines.

FOREST MANAGEMENT ON SWEDISH ESTATE[1]

By Sven Petrini
Translated by G. W. Hult

The Scandinavian forester's excursion through the forests of Sweden in 1921, included among other interesting examples of modern forestry, a visit to the largest estate in central Sweden, namely Ericsberg, located in the province of Ostrogothland. Ericsberg, entailed estate, has a beautiful park and imposing castle of historical interest, which dates back to the fourteenth century.

The estate is a part of a larger forest complex under the same management. The area of the entire forest complex is 28,332 hectares (70,008 acres), of which 64 per cent is forest land, 10 per cent is unreclaimable land and 26 per cent is farm land. Of this area, Ericsberg estate proper constitutes 62.5 per cent or 17,647 hectares (43,606 acres), having the same land distribution.

The forest on the estate is for the greater part mature to old. There are for instance considerable areas with stands of from 200 to 300 years old, a very large portion is from 100 to 150 years old, so that on more than 60 per cent of the forest area the age is over 60 years.

It is, of course, impossible under such conditions to attain a normal age-distribution in one stroke. The aim of the modern forest management since it was introduced along rational lines in 1910, has been to concentrate the limited labor supply on such cuttings as would serve to stimulate increased growth and to keep as large areas as possible in mature forest and to pay less attention to reproduction cuttings on a large scale.

Undoubtedly this principle has proved to be the right one. Only relatively small areas could be made ready by reproduction cuttings and if such cuttings had been large, it would have taken considerable time and expensive silvicultural work and at the same time a large loss in growth increment would have been unavoidable. After eleven years intensive cuttings, so much progress has been made that within a couple of years the respective stand will be cut over. The standing wood capital is of the best quality and the forest has been put in a

[1]Skogvårdsföreningens Tidskrift, May-June, 1922.

vigorous condition of growth, considering its age. The timber-cut consists of material of large dimensions, 27 per cent is charcoal wood, and fuelwood, the remainder is sawtimber.

As good winters (with sufficient ice and snow) cannot be counted on and as the possibilities for floating logs are few, the technique of timber transport has been carried on to a great extent by mechanical means. The transportation is so arranged that the sawtimber is transported during the winter by team to sawmill, lake, or river, while the smaller dimensions are teamed during the latter part of the winter to auto roads, to be carried later by truck to the railroad.

In this connection, engineer Dahlgren had demonstrated the importance of lowering the friction in vehicles. By using ball-bearings of a modern type, the cost of transportation can be considerably reduced. Putting in ball-bearings in wagon wheels has resulted in a 30 per cent increase of efficiency in road transportation. In teaming, it means that a larger load can be taken, and for auto-trucks it means a saving in benzine (or gasoline).

ECONOMIC EFFECT OF THINNING

Experiments to demonstrate the economic effect of thinnings were carried out on two experimental areas in pine forest, 110 years old, mixed with spruce. Area I had been thinned in 1910-1911. Area II is not thinned. The age for both areas is 110 years.

The unthinned area has 60 per cent greater number of trees than the thinned area, and the cubic content is 40 per cent higher. The value per hectar of the entire cubic volume, however, is only 14 per cent higher in the unthinned area, because the value per cubic meter here is eight kr. (about \$2.20) while the value per cu. m. in the thinned area is ten kr. (\$2.70). The growth-increment in cubic content is greater on the thinned area in spite of the lesser wood capital, as the volume on area I gives an increment of 5 m^3 per hectare per year (2.02 cu. m. per acre), while area II only gives a return of 3.5 m^3 per hectare (1.41 cu. m. per acre). Therefore area I gives a growth increment per year which is worth fifty kr. per hectare (or \$5.45 per acre), while area II returns only 28 kr. per hectare (\$3.06 per acre) on its greater wood capital. It follows from this that the thinned stand gives a much better rate of interest. Considering the comparatively old timber and the large dimensions, a high growth increment per cent could hardly be expected. But the thinned area

has twice as high rate of growth increment as the unthinned—1.34 per cent against 0.67 per cent. It is worth pointing out that here it is the largest trees which grow most vigorously, so that the width of the growth rings is greater the larger the trees are, and this holds true to some extent also regarding the growth increment per cent.

The quality increment per cent (increase of price per cubic meter on account of growing into larger dimensions) is for example for a pine of 35 cm. diameter outside bark, which grows to 40 cm. respectively, on area I, one per cent; on area II, 0.75 per cent per year. For a 25 cm. tree the comparison is 0.37 per cent and 0.12 per cent.

In this investigation the increase in diameter growth per year has been considered as being constant—and the bark has been deducted in the calculations.

Other thinning areas examined were located in 85-year mixed conifer forest, in 115-year mixed conifer forest with 540 m^3 per hectare (215 cu. m. per acre), and a value figured at 8,400 kr. per hectare ($920 per acre), and in 80-year spruce forest of No. 1 site quality (forest experiment station's area No. 546), where the average height is 28.5 meters. Of the greatest interest, however, is the experiment area of ½ hectare (1.23 acre), which demonstrated both the successful regeneration of pine, which could be attained under shelter wood system on these lands and the growth increment possibilities of the older stand. This shelter stand, under which very fine reproduction had come up to a number of 25,000 per hectare (11,214 per acre), of which 43 per cent are pine plants, consisted of not less than 400 trees per hectare (161 per acre), half of which is pine and half spruce. The age of the stand is now 120 years and all the spruce and a third of the pine have now been marked for the reproduction cutting. A heavy thinning took place in the stand in 1912-13 and a comparison, which was carried out with regard to the growth increment during the seven-year period which has elapsed since the thinning, and the growth increment which accrued in a seven-year period just before the thinning, indicates a surprisingly strong effect of the thinning.

It was found that the growth increment per cent of the basal area, during the seven-year period before the thinning, amounted to 0.94 per cent, but during the following seven years it was 1.42 per cent per year. In order to ascertain whether the increase in growth had been concentrated only on the lower parts of the boles, which would constitute a depreciation in the form class, a stem analysis was under-

taken, which showed that such was not the case. The sawed off sections, which had been used in the stem analysis study, were analyzed and the data worked up in the field. A map of the reproduction based on a 20 per cent estimate was also exhibited. Inspector Ruden made his acknowledgment of the results attained, but pointed out that although the pine on the Ericsberg forest showed an excellent sustained growth increment, shorter rotation periods would very likely prove more economical. The interest return would, however, be considerably better if a light-cutting were undertaken at the age of 75 years, when the growth increment, according to the stem analysis study began to decline more definitely. As against this, Professor Amilon answered that the quality of the growth increase is a factor which at that age plays an important role. On these favorable lands, quality material can and ought to be produced.

REVIEWS

Farm Woodlands. By James B. Berry. World Book Company, Yonkers on Hudson, New York. 1923. Pp. 425 + VI, fig. 163. $2.00.

This volume is one of the New-World Agriculture Series, issued under the editorship of W. J. Spillman. It carries as its sub-title, "A Textbook for Students of Agriculture in Schools and Colleges and a Handbook for Practical Farmers and Estate Managers." Professor Berry, the author, formerly Professor of Forestry at the University of Georgia, is now County Vocational Supervisor at Meadville, Pa., under the Pennsylvania State Department of Public Instruction. The chief interest to foresters in this book is that it is an attempt to cover a branch of the field of education into which forestry is only just finding its way.

The introductory chapter, "The Home Project in Woodland Forestry," discusses briefly the desirability of including the subject of woodland forestry in the four-year training period in vocational agriculture for high schools; "the content of the course being determined largely by farm, community, and regional needs and conditions." It is suggested that in a community of diversified agriculture the subject-matter in forestry might well be introduced into the third year work. Eighteen woodland projects are then listed, of which three are elaborated in considerable detail: Reorganization of the farm woodland on a profitable basis (a program in silviculture), Turpentine Orcharding, and the Preservative Treatment of Fence Posts. "Classroom instruction is based upon a critical analysis of the projects of possible interest to the community and consists of a discussion of the scientific principles which underlie the practice of woodland forestry. . . . In his project study the boy works out the further application of his technical knowledge to the specific needs of his project woodland. It is essential that the teacher should have definite knowledge of local conditions and keep clearly in mind the controllable factors of wood production. Unless he has had considerable experience in woodland management, he is in a position to derive as much benefit from the project as does the boy himself."

From this introduction one is led to expect a textbook especially adapted for use with such a course, notwithstanding the statement

that "the course of study outlined in the contents is merely suggestive in character" and that "each teacher must organize his own course based on local conditions." Instead of this, with the exception of a few suggestions in one or two of the chapters and a list of notes on supervised practicums, Professor Berry attempts, in the other 388 pages of the book, to cover pretty nearly the whole field of forestry as it concerns farm woodlands and other forest holdings of limited area. Certain of the chapter headings indicate the range of material included: Civilization and wood, forest influences, wood supplies of the world, the forest situation in the United States, stock taking, the improvement cutting, utilizing woodland products, the farm sawmill, woodland accounting, the production of turpentine, maple products, basket willow production, shade trees and their care, and clearing land.

It is a difficult task to condense into one volume such a wide range of topics. The book bears evidence of much hard work on the author's part . It is written in a good style and the illustrations are aptly chosen. Each chapter is followed by a list of references, for the most part to Forest Service and Experiment Station bulletins, and scattered through the text are tables from various authors that contain interesting data. Altogether the book brings together much useful information for readers not acquainted with the original sources. In various chapters, however, a considerable number of minor inaccuracies attract the eye of the professional forester. It is not necessary to enumerate these slips. A case in point is the statement on page 227 that circular quarter-acre plots may be laid out by "pacing out 60 feet from a central point." It may be questioned, too, whether some of the examples taken from practice in the Southern States will not be judged by the average reader to be of wider geographical application than was probably intended by the author. The context often fails to indicate that these examples apply only locally.

It is perhaps not within the province of the reviewer to comment here on the general topic of forestry as a vocational subject in high schools, but to the writer it would seem that the program indicated by Professor Berry is more elaborate than can successfully be carried out. It is obviously not to be expected that the vocational teacher in a high school shall have had a thorough education in forestry, followed by practical experience in forest management. But without such training he could hardly hope successfully to guide high school boys in detailed forestry projects that require both knowledge and

skill to bring them to satisfactory fulfillment. As everywhere in forestry, too, the time element enters into this question, for few forestry operations can be brought to completion in two, or even in four years. It may be questioned whether, at any rate at the start, vocational teaching in forestry should not be considered rather from the standpoint of supplementary extension work in forestry as it is now conducted in many of the states under the general leadership of the Farm Bureau.

The specific criticism of Professor Berry's book is that it covers so wide a field that it would seem difficult to use it as a text in the solution of specific, local problems in forestry. It is, however, only by trial that progress is made in any new field. Professor Berry deserves credit for his attempt to meet what he feels to be a distinct need.

The book is to be accompanied by three supplements containing guides for the identification of trees and of woods "in the three main forest regions of the United States," under the titles: Northern Woodlot Trees, Southern Woodland Trees, and Western Forest Trees. As the supplements were not ready for distribution when the book itself was sent for review, they have not been seen by the writer.

R. S. H.

Range and Pasture Management. By Arthur W. Sampson, M. A., Ph. D., University of California. John Wiley & Sons, Inc.

This volume is unquestionably more than welcome to a host of interests, among which naturally belong the student of range management, the stockman, Forest Service official, and, in fact, anyone connected with the growing of livestock and particularly sheep and cattle on Western range and pasture lands.

The author, who needs no introduction, is well equipped to appreciate the problems confronting the livestock industry, for he is not only a scientific investigator, but a stockman as well.

Very appropriately this book is dedicated to the author's father, a present-day middle Western stockman farmer of no mean ability.

The preface gives the book a three-fold purpose, namely: To encourage certain colleges to provide a place for this subject in their curricula; to aid those who are interested in the solution of certain problems in range management, and to serve as a text to those who desire a practical working knowledge of the subject, or those who may pursue technical grazing work as a profession.

There are four parts. Part I takes up the grazing industry and range conrol. Two very interesting chapters deal with our methods of grazing control in the United States, and the several classes of grazing lands, such as National Forests, State and private lands. The author is evidently an advocate of the slogan "Eat more meat," for he predicts the continuance of the meat-eating habit and expresses a doubt as to the popularity of meat substitutes. In reading the discussion of regions in which range lands are found, those living in the State of Texas are apt to voice just criticism at being left out of the Southwest.

The first chapter describes, in a very striking manner, the cause and effect of over-grazing, and ends with a touch of romance on range wars. Among the more important points brought out in Chapter 2 are the object and grazing policy of the National Forests, the increased carrying capacity of Western ranges, due to regulated grazing, and the leasing system and its benefits.

Included in Part II is a wealth of information on pasture revegetation and forage maintenance. Scores of stockmen have conjectured as to the feasibility of seeding range lands to cultivated, or native forage plants, that they might bring the range back, or increase the carrying capacity. A chapter devoted to this subject will enlighten many. Immediately following is found a chapter on natural reseeding and maintenance of range lands. This part is one of the most valuable in the book, from the standpoint of real worth to the rangeman, for it gives him the key to the situation. After having read that which comes under the heading "Requirements of Plant Growth" it is easy for one to appreciate why certain systems of grazing are conducive to forage production, while others are not. Strange as it may seem, we find that year-long protection on certain types does not accomplish the results with respect to reseeding that does the deferred system of grazing. The discussion of the palatability of mature forage is particularly interesting, and provides much food for thought.

The farmer, whose stock are confined to the limits of a pasture fence will find the chapter on "Improvement and Management of Farm Pastures" to be very profitable reading. How many know the difference between a sod and a bunch grass? This point may not seem to be of signal significance until one reads in the discussion that the success or failure of a pasture depends on this knowledge and the

application of the corresponding management, which, for one or the other, is widely different.

It has only been of recent years that those who have had to do with range and pasture lands have come to find out that many of these lands have, through excessive use and improper management, been gradually falling off in forage production. In many cases the awakening to this realization has been delayed until measures for the revegtation of such ranges will require years of careful and skillful management to bring them back to their former productivity. Chapter 6 of Part II tells in simple, every-day language just how one can recognize and correct a declining forage yield. It describes how destructive grazing can be recognized in its early stages before the productivity has been materially reduced, so that the stockman can apply the proper corrective measures as to the manner of stocking and thus check and remedy the impending damage. This has been made possible by the author's practical application of the scientific study of plant succession, not heretofore recognized in this light.

The two remaining chapters in Part II give a very comprehensive list and descriptions of the principal introduced forage plants, both grasses and non-grasslike. This is not a treatise on botany, but a description of the plants with particular refrence to their adaptability and use, the soil and climatic conditions best suited to them, and where they may best be grown.

Part III takes up range and pasture protection. It embodies a discussion of four of the principal agencies through which range and pasture lands are rendered less productive and offers practical protective measures relating to them. Throughout this part one finds that overgrazing plays its part and is a big influencing factor. In the chapter on "Control of Erosion on Range and Pasture" the author, who is an "erosion expert," shows in a most unique manner just what erosion is, its influencing factors, and the power it exerts on vegetative cover. The average reader will find that he little realizes the intimate relation of erosion to plant growth and revegetation, which is brought out very clearly. Aside from the fact that we all know erosion is a destroyer, one of the many points emphasized and which is probably not generally appreciated, is the inability of eroded soils, due to their decrease in fertility and capacity for holding moisture, to produce anything like what non-eroded soils are capable of doing. The keynote of the entire chapter is struck when one reads

"Remove the upper dark layer of humus soil and you have taken the productive part, the part you pay for when you buy the farm." The solution of the erosion problem is found at the end of the chapter summed up in five points, under the heading "How More Than Half of the Erosion Battle is Won." Here we find again that successful range and pasture management depends primarily upon the proper control of stock.

Those particularly interested in the use of the National Forests for grazing purposes will find good reading in the chapter on grazing and its relation to the future timber supply. Since the National Forests have been created chiefly for the purpose of growing timber, and the interests of many stockmen are centered in their use as range lands, it is of interest to know that grazing on these lands, although recognized as a limiting factor to timber production, can be regulated so that the conservation and furtherance of our timber resources will not be impaired. It is interesting to note that very logically the author's conclusion, as well as many others which are the result of exhaustive investigation in this phase of the work, have resulted in a system of regional application with respect to timber reproduction. So we find that in order to produce a satisfactory stand of reproduction, it is not advisable, in some regions, to graze sheep and goats, while the grazing of cattle and horses under the same conditions is safe. In another region it has been found that proper grazing, regardless of class of stock, is not detrimental to timber reproduction, and again it is pointed out that where artificial planting is necessary, exclusion of all classes of stock is paramount until reproduction is established.

The chapter on "Burning of Pasture Lands and Its Effect on Forage Production" should reap, as a just reward, a long line of supporters, some of whom have possibly labored under what the writer terms "a common delusion." After giving in a very vivid way the history of present-day burning, the author points out the why and wherefore of this practice, an analysis of which clearly shows that it does not take into consideration future productivity. Of the many salient facts brought out in the discussion of the "Effects of Burning on Forage Production" either on grass lands, brush lands, or wooded pastures and forest ranges, are: That the soil is robbed of the plant food elements, essential to vegetative growth; that the better and highly-prized perennial forage plants are replaced by inferior and unpalatable vegetation; that old growth serves both as

a feed and protection to the young growth, and finally that burning courts erosion. The use of goats for the purpose of eradicating brush is also mentioned, and it is shown how they accomplish good results without the ill effects of burning.

Each year vast sums of money are expended in the suppression of forest and range fires. Few realize the part grazing plays in fire protection. The subject matter under this heading tells how grazing reduces the fire hazard by the removal of a vast amount of inflammable forage, which, at the same time, is utilized to advantage. It has further been demonstrated that stock driveways have ofttimes served as adequate fire lines and breaks. Summed up we find that judicious grazing greatly aids and simplifies fire protection on forest and woodland ranges and, at the same time, increases the return from the land.

The last three chapters in Part III have to do with stock poisoning plants. The first of these takes up their control, which is of most importance in the far West, where the losses from poisonous plants on the National Forest alone amounts to half a million dollars annually. Very probably we all know one or two stockman who still take their losses each year from poisonous plants as a matter of course, yet these same stockmen would not for one moment tolerate such a loss due to theft. Much has been done, particularly on our National Forests, to eradicate certain of these poison pests. After telling what poison is, and giving the important families of poisonous plants, as well as a statement concerning their palatability to certain classes of stock, there is given a number of practical suggestions, which, if followed out and observed, will help in the reduction of losses from this cause. Particularly is this true where a range having poisonous plants, harmful to one class of stock, is given over to that class of stock to which the plants would be harmless. Proper salting has been found to be of importance in controlling these losses, as well as proper handling. It is also pointed out that natural salt or alkali licks whose deposits do not contain the essential chlorine elements are entirely unsuited to stock, and in no way take the place of common salt. Range stock should have sufficient salt for their needs at all times. A paragraph is devoted to the various methods of eradicating stock poisoning plants. The second chapter relating to this subject gives a very detailed and comprehensive write-up on the principal stock poisoning plants, with particular reference to their distribution,

distinguishing characteristics, symptoms of poisoning, parts and amounts of the plant necessary to cause death, best means of control and finally, remedy, if any. A very useful condensed table is given at the end, relative to symptoms and remedy for poisoning caused by five of the most common plants in this category. In conclusion, poisonous and mechanically injurious plants of secondary or local importance are dealt with, in which is given a goodly amount of data on numerous plants with which extensive feeding experiments have been carried on to determine their toxic qualities.

It seems as though there should have been a place in the book for general range improvements, other than those relating to stock water development. In Part IV, under the heading "Development of Watering Places for Range and Pasture Stock," the author places none too much emphasis on the importance of availability and distribution of stock water. This has a bearing not only on the welfare of the stock with respect to the distance they are required to travel to obtain feed and water, but of equal or even more importance is the proper maintenance of an even forage stand and even utilization of the forage crop, which is not possible where watering places are situated too far apart. The figures on water requirements of stock are interesting and of value. Those relating to the distance between watering places on level, rolling, and mountainous range are generally accepted by stockmen and range experts. Under the development of watering places, both natural and artificial, there are many helpful points and much useful data. It is thought that there are yet to be found many localities where experimentation with flood tanks, or earthern reservoirs constructed to catch flood water for stock purposes, would prove to be practical. The cost figures on wells and pumping equipment are perhaps too low as compared with present day prices.

In taking up the subject of range reconnaissance, the author limits himself to one chapter. Although brief, the discussion is very meaty, and much to the point. Perhaps too much so for the beginner. However, anyone interested in this subject can gain from the pages a good general idea as to the object, data required, procedure, and final analysis. The details and actual carrying out of the work are of course best learned in the field with a reconnaissance party. Possibly it would have been well to have included a write-up sheet on which the proper vegetative data had been recorded and worked up, and in connection with this a small palatability table for the species

listed on the write-up sheet. It is thought that by means of these illustrations a somewhat clearer understanding of the forage factor and its relation to the forage acre could have been had. The beginner, who has had timber reconnaissance work, will find the paragraph on timber and grazing reconnaissance compared very helpful. Perhaps a paragraph could have well been employed in a discussion of the relative accuracy of the three methods given under "Methods Employed in Obtaining the Data."

With respect to grazing capacity we find that due to variables and uncontrollable factors, the grazing capacity factor is very difficult to determine. This can be well appreciated by those who have had experience in certain sections of the southwest, which are subject to severe periods of drouth. Heretofore grazing capacity figures have been generally derived through estimates made by those who have had long years of experience with certain particular range lands. Naturally only a comparatively few individuals were capable of making reliable estimates of this kind. This limiting factor rendered accurate estimates of this kind difficult to obtain. The method now generally accepted and used by the Forest Service, in which the grazing capacity is based on reliable reconnaissance figures together with forage acre requirements of stock, eliminates this difficulty to a great extent and renders much needed data available in good form that would not otherwise be obtainable. Range men should be particularly interested in the acreage required to maintain certain classes of stock year-long under different conditions. These figures are the results from careful observations on widely different classes of range. A table giving in cow units the year-long grazing capacity of the National Forests from 1907 to 1921, inclusive, shows conclusively that regulated grazing results in increased carrying capacity. There is a long list of the salient points to be considered in range and pasture inspection. Anyone concerned with this work will find this subject dealt with in a very thorough manner.

Among present-day investigators, few, if any, are in a better position than the author to discuss the subject "Research Methods in Range and Pasture Management." While of only passing interest to the stockman, who cares more for results than how they are obtained, these pages will appeal more particularly to the investigator and student of rangement management. In them the reader is given an insight into the detail and technique required to accomplish this

phase of the work. It is by means of study involving work of this character, that many of the important and practical problems in range and pasture management are solved.

The book is concluded with a chapter on "Suggestions for Instruction in Pasture Management and Livestock Production." The prospective student will appreciate it for it tells him in great detail just what his educational requirements are and what should be embodied in his courses of instruction. The subject matter and extensive outline should be of no less interest in educational circles, not only because it is new, but because it gives specialization of this sort a place in the modern educational institution.

Readers will do well to take advantage of the literature referred to in the bibliography at the end of each chapter, which is in itself an education. Of special note are the many excellent and well-chosen photographic illustrations, which go to enliven and enhance the value of the book. At the end is an index which deals with the subject matter most exhaustively, and which renders it a ready reference.

The author is most assuredly deserving of high commendation for producing this, the first book of its kind, one which fills a distinct need.

J. D. Schoeller.

Fire Losses, Locomotive Sparks. By L. W. Wallace, M. E., Executive Secretary American Engineering Council of the Federated American Engineering Societies; former Professor Railway Mechanical Engineer, Purdue University. Barr Erhardt Press, Inc., New York, 1923.

This book embodies the result "of some five years of intense investigation of locomotive sparks and their relation to fires occurring along the right of way of American railways."

It is unquestionably the best treatise on the subject which has been produced. Foresters will find the work interesting and instructive reading. The conclusion of the writer may come as a distinct surprise to those individuals who have been in the habit of assigning all fires, starting within several hundred feet of a railroad line, to locomotive sparks as the cause of origin.

All phases of the subject are covered, among which may be mentioned the regulation of railroad fire hazard by State control and voluntary measures, descriptions of the modern steam locomotive, development of and problems connected with the locomotive spark

arrester, locomotive fuels and fuel combustion, spark material formation, the ignition properties of locomotive sparks, distribution of locomotive sparks, and locomotive spark fire prevention.

Portions of the book dealing with the fire-carrying characteristics, the ignition powers and distribution of locomotive sparks, will prove of particular interest to foresters.

The average annual loss to the railroads from railroad fires is given as about $12,000,000. In addition the extra costs for patrol, legal and other expenses, must bring the total up to between $15,000,000 to $20,000,000 a year.

In discussing spark arresters Mr. Wallace stresses the necessity of "consistent, regular, and thorough front end inspection and maintenance service" as essential if the ejection from the locomotive stack of large sparks is to be prevented. Draftac netting with 3/16 inch by 3/4 inch openings and strands of wire .135 inch in diameter is advised as furnishing good draft area and at the same time possessing strength and durability. Sparks larger than 3/16 inch in diameter cannot pass through this netting.

In testing the ignition properties of sparks carefully arranged field and laboratory experiments were conducted to determine the temperature at which locomotive sparks usually strike the ground and also the temperature at which sparks ignite combustible materials.

Paraffin, cotton fleece, and very dry excelsior and grass were used to test the ignition power of the sparks. The conclusions regarding the ignition power of sparks are so significant that they are quoted as follows:

"1. It is only when the temperature of sparks reaches 1,000° that they begin to possess the power to ignite combustible materials. At temperatures near the 1,000° lower limit this fact is confined to the larger sparks, those 1/2 inch or greater in size.

"2. It is only the larger sparks, 7/16 inch to 5/8 inch, abnormal in size, that become a menace between 1,000° and 1,400°.

"3. At temperatures beyond 1,400° with stimulating air currents the chances seem fair to start a fire if a spark of sufficient size comes in contact with dry combustible material in a properly loose and divided state, such as dead grass and pine needles. The experimental data show, however, that a spark, to possess the faculty of keeping 'alive' long enough to do this upon reaching the ground, must be larger than 1/4 inch. Smaller sparks, when heated above 1,400°, showed a tendency to burn themselves out so that they virtually amounted to ash before they travel far."

In regard to the temperatures at which sparks reach the ground, the author concludes that this temperature is not so high as 1,000° F. Even at temperatures of 1,000° to 1,200° F. it is only sparks greater than 1/4 inch in diameter which are capable of starting a fire.

Fifty-six pages are devoted to the experiments bearing on the distribution of locomotive sparks. These tests led to definite conclusions as to the distances to which sparks of various character were dispersed. A few of the more significant are given verbatim.

"1. The great bulk of all locomotive sparks, i. e., 83.5 per cent fall within the 50-foot zone paralleling the railroad track and fully 98 per cent fall within the 100-foot zone.

"2. The material which falls beyond the 100-foot zone consists of fine specks, dust, and the like which is harmless.

"3. Practically all sparks of definite weight and bulk fall within the 65-foot zone, and the greatest portion of these falls within the 50-foot zone."

Wind velocity, when greater than 20 miles an hour, influences the distances to which sparks are carried, but its influence is felt chiefly in scattering the finer material. The effect of wind velocity on the larger and heavier sparks appears negligible.

It is unfortunate that all the tests were conducted with locomotives equipped with spark arresting devices in proper repair. Since in practice most of the forest fires set originate from locomotives with defective spark arresters, it would be interesting to run a series of tests using a locomotive without a spark arrester for the purpose of determining the distribution of heavy sparks capable of starting fires.

The effect of wind velocities of from 20 to 40 miles per hour on the distribution of large sparks should also be further investigated by field tests.

In considering locomotive spark fire prevention, the author advises that the maximum size of spark escaping from the stack be kept below 1/4 inch in diameter. The best means of accomplishing this without impeding the draft is through use of Draftac with 3/16 inch by 3/4 inch openings. Unless such netting is regularly inspected and maintained, sparks of large enough size and sufficiently hot temperature will escape and cause fires.

Since all sparks large enough to ignite inflammable material fall within a distance of 100 feet from the center of the track, a fire line of that width kept free of inflammable material would prevent railroad

fires even though spark arresters were defective or not installed. Fires originating at distances greater than 100 feet from the center of the track cannot have been set by a spark from a railroad locomotive. These are logical deductions, if the conclusions reached by Mr. Wallace, after years of experimentation, are accepted. In this connection the following quotation from a statement [1] by Mr. C. P. Wilbur, State Forester of New Jersey, is of interest:

"In ten years' experience in New Jersey I know of but two instances when fire has started on a well-kept fire line or run into the woods, and of but one case where fire has been thrown by a locomotive beyond the 110 feet of fire line. In all of these instances it was in the flat southern country where the wind has uninterrupted sweep."

All evidence of scientific character at present available indicates that fires set by locomotive sparks are confined to zones close to the railroad tracks. And yet only recently a judgment was rendered making a railroad corporation liable for a fire which originated between 700 and 800 feet from their track.

If the belief, that most fires arising within several hundred feet of a railroad are railroad fires, has a basis of fact it is high time such basis was established.

For the present, the evidence so ably presented in Fire Losses, Locomotive Sparks by Wallace makes a strong case for limiting railroad liability to a narrow zone. Protection against railroad fires, particularly the construction and maintenance of fire lines, should be planned so as to utilize Mr. Wallace's conclusions. R. C. H.

Natural Reproduction of Western Yellow Pine in the Southwest. By G. A. Pearson. U. S. Department of Agriculture Bulletin 1105.

"The purpose of the study * * * is to determine what measures are necessary to secure natural reproduction." The climatic conditions in particular on the Coconino and Tusayan National Forests in Northern Arizona are admitted to be very unfavorable to regeneration after logging, and as early as 1904 Leiberg noticed considerable areas where no regeneration had taken place for from 20 to 25 years; therefore, if the Forest Service can solve the problem under these unfavorable conditions, regeneration on other more favorable areas will be easy and certain.

[1] Proceedings of the Northeastern States Forest Fire Conference held at Albany, N. Y., February 25 and 26, 1920, p. 62.

The author mentions "eight more or less interrelating factors" affecting regeneration: (1) seed supply, (2) climate, (3) soil, (4) herbaceous vegetation, (5) cutting, (6) brush disposal, (7) grazing and (8) miscellaneous enemies.

Seed crops are said to occur every 3 to 5 years, but because of the unfavorable climatic conditions at least 8 pounds per acre is considered a minimum annual seed requirement for average conditions, and Pearson argues that it is therefore necessary to have 3 to 5 seed treees per acre at least 21 inches in diameter breast high. If this is so and the next cut occurs in from 30 to 40 years, it would be interesting to know just what the loss in merchantable timber will be during this period. Even if this speedy second cut is practicable from the standpoint of relogging, it is possible that on many of these areas the reproduction period may last 30 to 40 years, or that regeneration will not be obtained at all within a reasonable period, and that planting may ultimately become necessary on portions of the forest.

The most important factor affecting regeneration seems to be climate; mainly because the rainfall is deficient and because it often occurs at the wrong time. Good second-growth is usually secured on sandy or gravelly soil. Compact clay soils are distinctly unfavorable. * * * "Properly regulated grazing appears to be the more practical means to control herbaceous vegetation," which is generally unfavorable to the new crop of seedlings because of root competition and shade. This agrees with the conclusions made 20 years ago in the chir pine forests of the Himalaya Mountains in British India. Properly regulated grazing can help regeneration, but improper sheep grazing is at present the largest controllable obstacle to reproduction of western yellow pine in the National Forests of the Southwest. It is of historical interest to note that as early as 1905-1906 an attempt was made by the reviewer to restrict sheep grazing after logging on the S. and M. sa'e areas in the interest of better regeneration.

Another important factor is root competition which often prevents young growth 50 to 75 feet from the base of the tree. Therefore, the conclusion is made that too many seed trees are almost as bad as too few—"4 to 5 choice seed trees * * * promise to give the best reproduction." Occasionally under favorable conditions the number of seed trees may be reduced to 3, but "the best results can be secured by the selection method of cutting * * * "

The author advocates piling and burning brush invariably when

there is advanced growth. Where there is little or no regeneration scattering seems to be preferred to pulling tops or lopping. Piling and burning is also advocated on bunch grass areas except on overgrazed or denuded clay soils or steep slopes. Exact data on loss of regeneration from diseases, insects and rodents do not appear to be available.

Pearson gives rules for the reproduction of western yellow pine under these unfavorable conditions:

"Encourage advance reproduction by instituting rigid protection against fire and grazing damage 10 years before a proposed cutting. Graze by cattle or horses sufficiently to hold grasses in check, but avoid overgrazing. Until it is demonstrated that sheep can be grazed with consistent safety to pine seedlings, they should be excluded from areas which are being restocked.

"If adequate advance growth occurs at the time of cutting, leave in addition to blackjacks only such trees as are needed for fire insurance and to seed up stump patches. If reproduction is lacking at the time of cutting, at least 4 good seed trees per acre above 20 inches in diameter should be left, unless natural conditions are known to be favorable, in which case the number may be reduced to 3.

"Burn the brush after logging wherever tall grass or other luxuriant ground cover occurs, and in all cases where reproduction is established, unless the brush is distinctly needed to check erosion. Where ground cover is light or of low stature, the brush may be scattered or pulled, though piling and burning is usually preferable. On compact soils, where ground cover has been destroyed, and on other bare soils, scatter the brush lightly.

"Keep out fire; kill rodent pests, including porcupines, gophers, rats, pine squirrels, rabbits, chipmunks, and mice; be on the lookout for disease and insect infestations."

T. S. W. Jr.

Decays and Discolorations in Airplane Woods. By J. S. Boyce. U. S. Dept. of Agriculture Bulletin 1128. February, 1923. Pp. 51, 7 color plates, 9 half tones. Bibliography of 75 numbers.

This bulletin describes the more important decays and discolorations to which woods used in aircraft construction are subject. Although aircraft woods are specifically mentioned, possibly because the study upon which the subject matter is based was on airplane woods, the bulletin has a much wider application, indeed instructors in pathology

and wood technology will find it admirable for reference use and in large part as a text.

A clear distinction is made between defects and discolorations not due to decay, and discolorations indicating the presence and extent of dangerous fungi. Among the woods receiving attention are the most important airplane woods and their substitutes—spruce, Port Orford cedar, Douglas fir, white pine, western hemlock, true firs, yellow poplar, basswood, ash, maple, oak mahogany, walnut, birch and others. The list really includes many of our principal commercial species.

About eight pages are devoted to a discussion of general defects, such as diagonal grain, brashness, compression wood, compression failures, shakes, pitch pockets, etc., and the relation between density and strength, the effect of steaming dried wood, the desirability of seasoning, and faulty design and assembly.

Nearly thirty pages discuss color comparisons, that is, variations in color, natural color changes, color as an index of strength; discolorations caused by wounds and fungi and those of a chemical nature. Among the wound discolorations are those resulting from lightning and sapsuckers, each being given detailed description. Economically, discolorations caused by fungi are the most important. That part of the bulletin devoted to these would of itself serve as a good student text. The causes and control of the several types of stains and decays are very carefully described and the importance of searching for incipient decay is emphasized. Among the decays described are the ring-scale fungus, sulfur fungus, velvet-top fungus, incense-cedar dry rot, Indian paint fungus, ash Fomes, false tinder fungus, oak fungus, and dry-rot fungus.

Adding greatly to the value of the bulletin are seven plates showing very truthfully in colors the appearance of eight of the most important discolorations caused by fungi. It is said that few if any other U. S. D. A. bulletins have so many color plates. E. F.

A Study of Deciduous Fruit Tree Rootstocks with Special Reference to their Identification. By Myer J. Heppner. University of California Publications, Technical Paper No. 6. June, 1923. University of California Press, Berkeley, Calif. Pp. 25, plates 6.

Although primarily a horticultural topic the subject of this publication is of interest also to wood technologists inasmuch as it is con-

cerned with the microscopic structure of root stocks. As is well known, many valuable varieties of fruit and nut trees are grafted on root stocks of other varieties or even species, thus combining the fruiting habit of the one with the root vigor of another. The species or variety of root stock used has not always been made a matter of record in the past with the result that if the combination root stock and scion prove to be a desirable one the grower is at a loss to know how to repeat it. Consequently it becomes desirable to determine methods for the identification of root stocks.

In this bulletin the author has made a study of the possibility of basing this identification on the external characteristics of root portions and on their anatomical structure. A survey of existing literature must have been discouraging because it seemed "to indicate that the identification of the various deciduous fruit root stocks by morphological or historical characters would be practically impossible." As a result of the investigation, however, he has been able to detect slight variations more or less constant in nature, and upon such as are easily interpreted he has prepared a key for distinguishing between the principal species of root stocks used in California. The key is based first on ray widths, then on the presence or absence of calcium oxalate crystals in cells directly under the cork layer and the character of the ray extensions into the cortex or the size of the cortex cells. Further differentiation is based largely on bark color, bark taste, or the relative size of lumen and cell wall; lenticels, tracheal and wood parenchyma characteristics, etc. The material used in the investigation included specimens of almond, apricot, peach, cherry, plum, pear, apple, and quince. The key endeavors to separate these and several of their varieties. It was found that certain species of roots of strikingly different above-ground characters had very similar underground characteristics, also, "ecological variations cause marked differences in gross morphological and certain anatomical features of fruit tree root stocks."

Six plates carrying 19 photomicrographs are appended. A list, which should be helpful to others making a microscopic study of the anatomy of a wood stem or root, is given in the text covering the many characteristics examined by the author, such as number and arrangement of bast fibers, ratio between width and length of cork cells, cell width of medullary rays, character of pitting, size, arrangement, and number of trachea, and many others. E. F.

Oleoresin Production. By Eloise Gerry. Bulletin 1064, U. S. Dept. of Agriculture.

This bulletin describes an investigation undertaken to obtain by means of microscopic study, information on the changes which result from turpentining in the wood of the pines. "Changes produced by turpentining which were registered in the internal anatomy of the pines were studied, not only in the completed annual ring at the end of the season, but also particularly in specimens obtained periodically throughout the year." This method of attack brought out some very interesting and useful information. For example, it was determined that the gum which exudes during the first weeks of a newly chipped tree comes from the normal resin ducts or passages already present, and that it is often a month or more before new resiniferous tissue has been formed to add to the yield. This disproves a belief that the heavier yield experienced where a single streak is made some weeks in advance of the regular chipping is due to the formation of secondary resin ducts immediately following wounding. The resin ducts formed after wounding, once the formation of resiniferous tissue has begun, are more numerous than normally. This secondary tissue adds materially to the flow of oleoresin, but the author says "it seems doubtful if they make up the chief source of the commercial crude turpentine," a belief based on earlier Forest Service experiments. The three methods under experiment were (1) the standard method of the cooperator, (2) double chipping, and (3) narrow chipping. Wood samples, from a point midway between the corner and peak of each streak were taken periodically. These were examined under the microscope and a study made of the progress of growth during the chipping, the prevalence of resin ducts, the number of tracheids, etc. Each of the three methods of chipping was judged, not only by the amount of resin obtained, but also by its effect on the vitality of the trees as indicated by the wood tissue produced and as revealed by the microscope. It was demonstrated "that those methods which conserve the vitality of the tree and its responsive power, under stimulation such as is given by turpentining, insure the greatest production of oleoresin." The effect of turpentining on the wood structure was found to be nothing in the wood formed before turpentining, but in the wood formed after turpentining began there was considerable modification: the resin passages were found to be more numerous than normally and they formed earlier in the growth ring. The effect in

a circumferential direction was slight but vertically, the response to the wound stimulus was greatest within a foot above the last streak. Comparing the three methods, the microscopic study showed that (1) the standard method of chipping resulted, along with other undesirable results, in decreased wood production, decreased vigor, and decreasing yield; (2) the double chipping resulted in a "decidedly detrimental influence on wood formation and on the general vitality of the timber," and an insufficient "increase in yield to offset the additional cost of turpentine operations lasting for a considerable number of years;" (3) narrow chipping was found to result in higher sustained yields, little reduction in wood formation, high production of resiniferous tissue, low death rate and unreduced responsive vigor, in addition, there is greater ease of operation.

The bulletin is well illustrated with photomicrographs of specimen sections showing the effect of turpentining on the structure of the wood. E. F.

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Compiled by Helen E. Stockbridge, Librarian, U. S. Forest Service.

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SOCIETY AFFAIRS

Membership

The following men have been elected to membership in the Society, effective December 8, 1923:

Members

Joseph E. Abbott, Toms River, N. J.
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James F. Dubuar, Wanakena, N. Y.
Raymond J. Hoyle, Syracuse, N. Y.
G. H. Lentz, Syracuse, N. Y.
Leonard E. Newman, Concord, N. H.
Oliver M. Porter, New York City.
C. E. Rachford, Washington, D. C.
Arthur W. Sampson, Berkeley, Calif.
H. M. Sears, Bristol, Tenn.
John B. Taylor, Butte, Mont.

Associate Member

Axel H. Oxholm, Washington, D. C.

New York Section

The summer meeting of the New York Section was held at Cranberry Lake, N. Y., August 16 and 17. Col. H. S. Graves spoke on the national forestry program. O. Meyer read a paper on the yield and growth of spruce, and a paper by A. B. Recknagel on the growth of white spruce in the Adirondacks was read. S. T. Dana outlined the plans of the new Northeastern Forest Experiment Station, and resolutions were adopted favoring the organization of an advisory "forest research council" to cooperate with the station. It was suggested that a joint meeting with the New England Section be held at Petersham, Mass., next summer.

Walter S. Rohde

Notice has been received of the accidental death of Walter Stewart Rohde, of Wilkes-Barre, Pennsylvania, November 22. Rohde was

elected Member of the Society October 18, 1923. He was born May 13, 1897, was educated in the Wilkes-Barre schools and graduated from the Pennsylvania State Forest Academy at Mont Alto in 1919, with the degree of Bachelor of Forestry. From March, 1920, until his death he was employed as forester by the Spring Brook Water Supply Company of Wilkes-Barre.

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